

Facial Plastic Surgery

The Essential Guide

Stephen S. Park

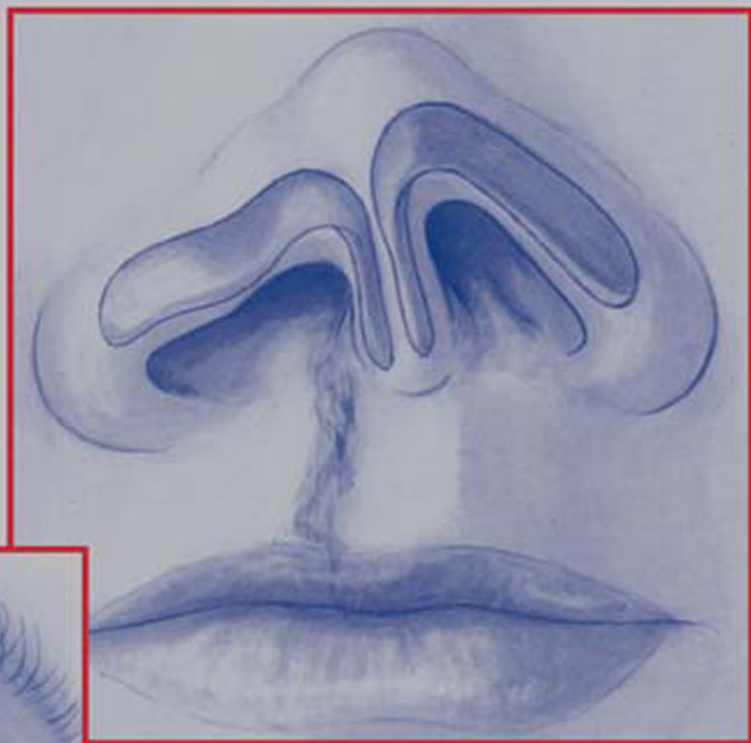
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The Essential Guide

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Dedications

I would like to dedicate this book to the influential men who taught me most about the art of medicine, living with success and failure, and the strength in teaching. Ted Cook, Tom Wang, Paul Levine, Stanley Shapshay, Nabil Fuleihan, and Werner Chasin (deceased) have always been the cornerstones of my education and I will remain eternally grateful to them. Behind the completion of every successful project is a family that remained patient, supportive, and unconditional. Eileen has been all that and more. As always ...

Stephen S. Park, M.D.

In any undertaking of this magnitude there are countless hours of unrecognized labor on the part of the office staff and fellows and to them I am forever thankful and appreciative. The greatest thanks have to go to those who have dedicated their professional lives to facial plastic surgery and the imperative role it plays in otolaryngology and to the foundation that otolaryngology gives facial plastic surgeons to be the most qualified specialists practicing plastic surgery in the head and neck. There is none more deserving of this thanks and praise than Richard T. Farrior, a pioneer in facial plastic surgery who never lost touch with his roots in otolaryngology. Thanks Dad!

Edward H. Farrior, M.D.

I dedicate this work to my wife Colleen and my two daughters Hannah and Olivia.

Dean Toriumi, M.D.

I would like to thank my wife Debra for her support in this important project. I would also like to thank Dr. Charlie Cummings for his support of my academic career and Dr. Ted Cook for the mentorship he has always provided.

John Frodel, M.D.

To my parents Ernest and Frances Day, my wife Millie and my children Austen and Meredith for the inspiration and support that allowed me to offer the highest quality patient care and education to our future clinicians.

Terry Day, M.D.

To my late mother Harriet, who taught me how to write. To my father Ed, who taught me to treasure each day.

Jonathan Sykes, M.D.

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Foreword

This text is precisely what it claims to be. It is a comprehensive guide to the essential elements of facial plastic and reconstructive surgery.

Dr. Stephen Park and his colleagues have produced in six extensive, well-written and well-illustrated chapters a book which covers in depth the knowledge needed to study facial plastic surgery. They have taken the material which they have used in the past for a course given annually for residents at the AAO/HNS fall meeting and thoroughly expanded it to make each chapter a nearly stand alone reference. Each of the authors is fellowship trained, but more than that, each one has pursued additional training in his own subspecialty focus area, and each has quite literally become a widely respected expert and teacher in that field. In turn

each has produced a thorough treatise on his own area of expertise. When taken as a whole, these six chapters provide an excellent overview of facial plastic surgery.

Facial Plastic Surgery: The Essential Guide is a delight to read and the drawings and photography make it a *very* effective teaching and learning resource. It should be an essential reading and reference material for residents, fellows, and practitioners with any interest in facial plastic surgery. I congratulate Dr. Park and each of his five colleagues for producing a work which so thoroughly meets its stated title and purpose.

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Preface

This is a project designed to cover the *essentials* of facial plastic surgery in its entirety, targeting the younger physician or the individual just beginning a plastic surgery practice. It is not a comprehensive, multi-volume text on the nuances of medicine or a surgical atlas. Our aim is to touch on all components of facial plastic surgery (congenital problems, maxillo-facial trauma, head and neck reconstruction, rhinoplasty, aging face surgery, and cutaneous reconstruction). This text can best be used as a starting foundation, to be read cover-to-cover, from which one builds vertically with additional courses, references, and clinical experiences.

The co-authors are widely recognized as international authorities on their respective topics and they have dedicated a tremendous number of hours toward this final product. One may notice that they

are the sole authors of each chapter. This individual investment has resulted in an eloquent and personal narrative that is the direct opinion of the expert. These efforts reflect the commitment toward education and a belief in the sharing of ideas across generations, disciplines, and colleagues.

Like any major production, this project only came to fruition through the tremendous efforts and support of many individuals, from families to secretaries, mentors to patients, who are too numerous to list. Specific gratitude must be extended to Ms. Esther Gumpert and Birgitta Brandenburg from Thieme, whose gentle perseverance pushed this project through.

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SYNDROMES AND CONGENITAL ANOMALIES

Jonathan M. Sykes

Congenital anomalies are often complex, and may have significant physical and psychological impact. Successful management of the child with a congenital anomaly may require knowledge of genetics, pediatrics, molecular biology, and reconstructive surgery. An interdisciplinary team should include a speech therapist, social worker, pediatrician, geneticist, orthodontist, oral surgeon, audiologist, and cleft/craniofacial surgeon. Other specialists such as a neurosurgeon, ophthalmologist, or otologist may be necessary to provide the patient with comprehensive care. It is very important to address the psychosocial and genetic concerns of the patient and family. Although care of the patient with a cleft or craniofacial anomaly often demands a multidisciplinary effort, successful treatment is extremely rewarding.

TYPES OF CONGENITAL ANOMALIES

To understand human morphogenesis, a classification system for congenital anomalies is necessary. Most structural defects can be categorized into one of three general categories of developmental pathology: malformations, deformations, or disruptions (Table 1–1).¹ The clinical manifestations and implications of each category of anomalies are different.

A *malformation* is a morphologic defect of an organ, part of an organ, or a larger area of the body resulting from an intrinsically abnormal developmental process. A malformation sequence exists when there is a single localized poor formation of tissue that initiates a chain of subsequent defects. Malformation sequences occur in all types of expression, the manifestations ranging from nearly normal to extremely severe, and have a recurrence risk that is most commonly in the 1 to 5% range.² Polydactyly, cleft lip, and renal agenesis serve as examples of malformation sequences. Malformations may be relatively simple or complex. The later in utero that a malformation defect is initiated, the simpler the malformation. Malformations initiated earlier in embryogenesis

tend to have more significant consequences on the organism.

A *deformation* is an abnormal form or position of a part of the body caused by nondisruptive mechanical forces. In a deformation sequence, there is no problem in the embryo or fetus, but mechanical forces such as uterine constraint result in altered morphogenesis, usually of the molding type. An example of a deformation sequence is oligohydramnios. This sequence is due to chronic leakage of amniotic fluid. Another deformation sequence is the breech deformation sequence, which occurs from prolonged breech position late in fetal life. Other deformations include clubfoot, congenital hip dislocation, and congenital postural scoliosis. Deformations usually arise during late fetal life and have a very good to excellent prognosis, in contrast with the prognosis of many malformation sequences. Because the most common cause of deformation is intrauterine molding by mechanical forces, the musculoskeletal system is usually affected. Deformations may result from mechanical, malformational, or functional causes. The recurrence risk for deformation is usually very low, unless the cause of the deformation problem is a persisting one, such as a bicornuate uterus.³

A *disruption* is a morphologic defect of an organ, part of an organ, or a larger region of the body resulting from a breakdown of, or interference with, an originally normal developmental process. In this scenario, a normal fetus is subjected to a destructive problem and its consequences. Disruptions may be of vascular, infectious, or even mechanical etiology. An example of a disruption sequence is the disruption of normally developing tissues by amnionic bands. An amputation of a digit in utero caused by an amnionic band or other band-caused disruptions such as ring constriction are other examples of disruption sequences. In uncommon cases, amnionic bands can cause dramatic manifestations such as asymmetric encephaloceles, bizarre facial clefting, and limb amputations.

There is a fourth mechanism of abnormal morphogenesis. It is *dysplasia*, in which there is a lack of normal

TABLE 1-1 CHARACTERISTICS OF CONGENITAL ANOMALIES

<i>Features</i>	<i>Malformations</i>	<i>Deformations</i>	<i>Disruptions</i>
Time of occurrence	Embryonic	Fetal	Embryonic/fetal
Level of disturbance	Organ	Region	Area
Perinatal mortality	+	–	+
Clinical variability of any given anomaly	Moderate	Mild	Extreme
Multiple causes of any given anomaly	Very frequent	Less common	Less common
Spontaneous correction	–	+	–
Correction by posture	–	+	–
Correction by surgery	+	±	+
Relative recurrence rate	Higher	Lower	Extremely low
Approximate frequency in newborns	2–3%	1–2%	1–2%

Modified from Cohen MM Jr. *The Child with Multiple Birth Defects*, 2nd ed. New York: Oxford University Press, 1997.

organization of cells into tissue.⁴ Hamartomas are examples of dysplasia sequence. This anomaly represents an abnormal organizational defect resulting in tumor-like formation of tissues. Some of these tissues have malignant potential. Examples of hamartomas are hemangiomas, melanomas, fibromas, lymphomas, adenomas, and other tumors that are not easily classified.

RELATIONSHIPS BETWEEN TYPES OF ANOMALIES

Understanding of normal morphogenesis allows an interpretation of structural defects, and the study of structural defects aids in the understanding of normal morphogenesis. Each anomaly must have an understandable development and cause. Although distinctions among malformations, deformations, and disruptions are clinically useful in the newborn period, the three types of anomalies are somewhat interrelated during growth and development after birth.

A *sequence* describes a pattern of structural defects in which all of the anomalies in the patient can be explained on the basis of a single problem in morphogenesis that leads to a cascade of subsequent defects. An example of such a sequence is the Robin sequence.⁵ The single initiating defect of this disorder may be hypoplasia of the mandibular region prior to 9 weeks in utero.⁶ The mandibular hypoplasia allows the tongue to be posteriorly located, thereby impairing the closure of the posterior palatal shelves that must overgrow the tongue to meet in the midline. This results in a U-shaped cleft palate. The resultant triad of mandibular hypoplasia, glossoptosis, and U-shaped cleft palate is referred to as the Robin sequence. This sequence may be malformational or deformational, depending on the initiating factor intrinsic mandibular hypoplasia (malformational) or extrinsic mandibular constraint (deformational).

Although malformations, deformations, and disruptions can be distinguished as separate types of congenital anomalies, these classifications may be combined in some abnormalities. For example, some congenital malformations such as cleft lip and palate have secondary deformations. Although the original developmental anomaly is a malformation, the resulting secondary deformity occurs with growth and development of the organism. If a congenital abnormality is produced by the administration of a teratogen during pregnancy, the resulting facial abnormality is known as a deformation. This deformation occurs secondary to the original disruption created by the teratogen. The comparison of malformations, deformations, and disruptions usually does not have a significant affect on treatment philosophy. However, the distinction between these congenital anomaly types is important prognostically and in terms of relative recurrence risks.

SYNDROMES

A *sequence* is defined as a single problem in morphogenesis that leads to a series of subsequent defects. Although often called syndromes, sequences are not true syndromes in the medical genetic sense. A *syndrome* is defined as multiple structural defects occurring in embryonically noncontiguous areas. These structural defects cannot be explained on the basis of a single initiating defect and its consequences, but rather appear to be the result of multiple defects in one or more tissues. An example of a syndrome in a child is congenital cleft lip and palate, genital malformations, and syndactyly of the toes. Although these malformations are embryonically noncontiguous, they are commonly thought to be due to a single cause. The known etiologies for malformation syndromes include chromosomal abnormalities, mutant gene disorders, and environmental teratogens.

There are many syndromes for which the etiology has not been determined.

Syndromes result from an interaction among genetic factors, molecular and cellular events, mechanical and deformational forces, and secondary effects of each of these on normal growth and development. A known syndrome is identified by a series of symptoms and signs that characterize an abnormal condition or disease state. Many malformation syndromes have distinctive facial appearances. Some of the dysmorphic features associated with these syndromes are easily identifiable, whereas others are difficult to describe or quantify. To become good at recognizing syndromes, physicians must train their eyes to recognize variations from normal, and must synthesize and collate these variations into recognizable patterns. The following sequences and syndromes include commonly recognizable craniofacial anomalies.

ROBIN SEQUENCE

The commonly seen triad of micrognathia, cleft palate, and glossoptosis was named after Pierre Robin,⁵ who reported the condition in 1923. However, the combination was described earlier by St. Hilaire in 1822, Fairbairn⁷ in 1846, and Shukowsky⁸ in 1911.

The initiating defect of the Robin sequence (often mislabeled Pierre Robin syndrome) is mandibular hypoplasia occurring prior to 9 weeks' gestation. Latham⁹ studied a 17-week-old fetus with Robin sequence that had significant early mandibular retrognathia. The mandibular retrognathia associated with the Robin sequence pushes the tongue posteriorly and superiorly and impairs normal embryonic closure of the posterior palatal shelves, which normally close in an anterior-to-posterior fashion at between 8 and 12 weeks gestation.¹⁰ This closure begins anteriorly at the foramen cecum. The

relative glossoptosis gives rise to a secondary U-shaped cleft palate. The extent of the palatal cleft is related to the degree of mandibular retrognathia (Fig. 1-1).

Birth prevalence estimates have varied from 1/2000 to 1/30,000.¹¹ Bush and Williams¹² have suggested that the incidence of this sequence is 1/8500 births. Although the traditional definition of the Robin sequence includes the triad of micrognathia, cleft palate, and glossoptosis, Williams et al¹³ have cautioned against assuming that every infant with cleft palate and micrognathia has the sequence. In their review, they indicated that respiratory difficulty is an essential component of the Robin sequence.

Although the Robin sequence is usually a malformation sequence, the condition can also result from early in utero mechanical constraint, with the chin being compressed in a manner to limit its growth prior to palatal closure. The manifestations of this deformation sequence are similar to the clinical condition of the malformation sequence.

The Robin sequence can be associated with other congenital abnormalities and therefore be part of a syndrome (Table 1-2). Examples include Treacher Collins syndrome (mandibulofacial dysostosis, del [22q11.2] syndrome, and Stickler dysplasia syndrome).⁶ In syndromic forms of the Robin sequence, the mandible usually does not exhibit catch-up growth; rather, the mandible lags behind expected normal growth. In the deformational sequence form of the Robin sequence (due to intrauterine constraint), the mandible also does not catch up and grow to its expected size.¹⁴ These conditions are in contradistinction to the malformational form of Robin sequence, in which the mandible typically grows to normal size. Other syndromes in which Robin sequence may be a feature with variable frequency are listed in Table 1-3.¹⁵

In all cases of Robin sequence, the posterior airway obstruction must be carefully evaluated and treated. This



FIGURE 1-1 (A) A 4-month-old girl with Pierre Robin sequence and obvious retrognathia. This patient also had relative macroglossia and a U-shaped cleft palate. (B) Close-up intraoperative view of a patient with U-shaped cleft palate. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

TABLE 1-2 ROBIN SEQUENCES AND COMPLEXES

<i>Condition (Sequence or Complex)</i>	<i>Cause</i>	<i>Mandible</i>	<i>Cranial Base Angle</i>	<i>Respiratory Compromise</i>
<i>Malformation</i>				
Treacher Collins syndrome (mandibulofacial dysostosis) (sequence)	Mutations in <i>TCOF1</i> (gene map location: 5q32–q33.1)	Short body Short ramus Characteristic shape Growth severely affected	Decreased	Pharyngeal
del (22q11.1) syndrome* (complex)	del (22q11.2)	Retrognathia Essentially normal in shape	Increased	Hypotonia
Deformation (sequence)	Intrauterine constraint	Short body Short ramus Increased gonial angle Incomplete catch-up growth	Decreased	Pharyngeal
<i>Connective tissue dysplasia</i>				
Stickler dysplasia (complex)	Heterogeneous Mutations in <i>COL2A1</i> (gene map location: 12q13.11–q13.3) (protein: type II collagen) Mutations in <i>COL11A1</i> (gene map location: 6p21.3) (protein: type XI collagen)	Short ramus Antegonial notching of body	Decreased	Pharyngeal
Spondyloepiphyseal	Mutations in <i>COL2A1</i> (gene map location: 12q13.11–q13.3)	Short body		Small mechanically abnormal chest and/or tracheobronchomalacia and/or cervical instability (resulting in central apnea)
Dysplasia congenital (complex)				

*Formerly known as velocardiofacial syndrome, DiGeorge syndrome, or conotruncal anomalies/face syndrome.

From Cohen MM Jr. Robin sequences and complexes: causal heterogeneity and pathogenetic/phenotypic variability. *Am J Med Genet* 1999; 84:311. (From Lin KY, Ogle RC, Jane JA. *Craniofacial Surgery*. Philadelphia: WB Saunders, 2002.)

may involve placing the child in the prone position, placing a nasopharyngeal airway, or doing more invasive procedures such as a lip–tongue adhesion or even a tracheotomy.¹⁶ The airway obstruction can be significant and lead to hypoxia, cor pulmonale, and occasionally failure to thrive. Affected children should be carefully monitored, especially during the first few weeks of life.

MANDIBULOFACIAL DYSOSTOSIS (TREACHER COLLINS SYNDROME, FRANCESCHETTI-ZWAHLEN-KLEIN SYNDROME)

The Treacher Collins syndrome was first reported in 1846 by Thompson¹⁷ and Toynbee¹⁸ and was later described by Treacher Collins¹⁹ in 1900. The more accurate term

mandibulofacial dysostosis was first given to this syndrome by Franceschetti and Klein²⁰ during the 1940s. This abnormality has several common features (Table 1–4).

The constellation of abnormalities in Treacher Collins syndrome is easily recognizable by the significant mandibular hypoplasia and malar hypoplasia (Fig. 1–2). The zygomaticomalar hypoplasia results in a weakness in the lateral orbital rim and the associated soft tissues of the lower eyelid (Fig. 1–3). This causes an antimongoloid slant to the palpebral fissures of the eye. There are also commonly other first branchial arch defects, which include malformation of the auricles, defects of the external auditory canal, and conductive hearing loss. Occasional abnormalities include pharyngeal hypoplasia,²¹ coloboma of the upper eyelid, choanal atresia, and

TABLE 1-3 SOME REPRESENTATIVE CONDITIONS ASSOCIATED WITH ROBIN SEQUENCE

Condition
<i>Monogenic</i>
Beckwith-Wiedemann syndrome
Campomelic syndrome
Carey neuromuscular syndrome
Catel-Manzke syndrome
Cerebrocostomandibular syndrome
Congenital myotonic dystrophy
Diastrophic dysplasia
Donlan syndrome
Mandibulofacial dysostosis
Miller-Dieker syndrome
Nager acrofacial dysostosis
Otopalatodigital syndrome II
Persistent left superior vena cava syndrome
Popliteal pterygium syndrome
Postaxial acrofacial dysostosis
Radiohumeral synostosis syndrome
Robin-oligodactyly syndrome
Spondyloepiphyseal dysplasia congenita
Stickler syndrome
Velocardiofacial syndrome
<i>Chromosomal</i>
Del (4q) syndrome
Del (6q) syndrome
Dup (11q) syndrome
<i>Teratogenically induced</i>
Fetal alcohol syndrome
Fetal hydantoin syndrome
Fetal trimethadione syndrome
<i>Disruption</i>
Amniotic band sequence
Unknown genesis
CHARGE association
Femoral dysgenesis-unusual facies syndrome
Martsolf syndrome
Moebius sequence
Robin/amelia association
Sickle-shaped scapulae and club feet

TABLE 1-4 COMMON ABNORMALITIES OF MANDIBULOFACIAL DYSOSTOSIS

Abnormal Chart	%
Antimongoloid slanting palpebral fissures	89
Malar hypoplasia, with or without cleft in zygomatic bone	81
Mandibular hypoplasia	78
Lower lid coloboma	69
Partial to total absence of lower eyelashes	53
Malformation of auricles	77
External ear canal defect	36
Conductive deafness	40
Visual loss	37
Cleft palate	28
Incompetent soft palate	32
Projection of scalp hair onto lateral cheek	26

**FIGURE 1-2** Lateral view of a 9-month-old with mandibular and malar hypoplasia and malformation of the auricles.**FIGURE 1-3** Patient with significant zygomaticomalar hypoplasia resulting in weakness of the lateral orbital rim and a secondary antimongoloid slant to the palpebral fissures of the eye.

congenital heart defects. The occasional abnormalities associated with this syndrome are listed in Table 1-5.²²

The genetic etiology of Treacher Collins syndrome is autosomal dominant with 60% of the cases representing fresh mutations. The genetic map location for this abnormality is 5q32-33.1. Patients with Treacher Collins syndrome often develop respiratory problems as a result of the mandibular hypoplasia and narrow oropharyngeal airway. Occasionally, patients with mandibulofacial

TABLE 1-5 OCCASIONAL ABNORMALITIES OF MANDIBULOFACIAL DYSOSTOSIS

<i>Occasional Abnormal Chart</i>
Pharyngeal hypoplasia
Coloboma of the upper lid
Dacrostenosis
Microphthalmia
Strabismus
Ptosis
Macrostomia
Microstomia
Choanal atresia
Blind fistulas and skin tags between auricle and angle of the mouth
Absence of the parotid gland
Congenital heart defect
Cryptorchidism
Mental deficiency 5%

dysostosis require tracheotomy (Fig. 1-4). These patients should be carefully monitored and tested for hearing loss and for visual loss. Otologic and ophthalmologic consultation is recommended.

STICKLER SYNDROME (HEREDITARY ARTHRO-OPHTHALMOPATHY)(MARSHALL-STICKLER SYNDROME, WAGNER-STICKLER SYNDROME)

In 1965, Stickler²³ observed five generations of one family with affected individuals, noting facial characteristics of flat facies and depressed nasal bridge with midfacial or



FIGURE 1-4 Patient with mandibulofacial dysostosis requiring tracheotomy. Note the coloboma of the lower eyelids, and the downward slanting of the poorly supported lateral canthi of the eyelids.

mandibular hypoplasia. The complete manifestations of the Stickler syndrome were elaborated by Herrmann et al,²⁴ who additionally noted myopia and spondyloepiphyseal dysplasia. Stickler syndrome consists of abnormalities in the orofacial region, the eyes, and the musculoskeletal system (Fig. 1-5). The facial abnormalities consist of flat facies, secondary cleft of the hard or soft palate (20%), Robin sequence, sensorineural and conductive hearing loss (80%), epicanthal folds, and midfacial or mandibular hypoplasia.²⁵ These patients have significant myopia of 8 to 18 diopters (75-80%). This myopia is usually present before the age of 10 years. The patients also can have chorioretinal degeneration, retinal detachment, or cataracts.

The musculoskeletal system in patients with Stickler syndrome can have various manifestations.²⁶⁻²⁸ These include hypotonia, hyperextensible joints, marfanoid body habitus, scoliosis, and other severe arthropathies. The patients can have subluxation of the hips and other joints in mild to moderate spondyloepiphyseal dysplasia. Secondary degeneration of the articular surface of joints can occur in adulthood. Other manifestations of Stickler syndrome include mitral valve prolapse, which occurs in 46% of patients.²⁹

All patients found to have the Robin sequence at birth should be considered possible candidates for Stickler syndrome.^{30,31} It has been suggested that 30% of infants with Robin sequence are eventually diagnosed with Stickler syndrome. This is particularly true in any patient with a family history of cleft palate or in any patient with congenital myopia or retinal problems. Ophthalmologic consultation should be obtained at approximately 3 to 6 months of age, and the patient should get retested at about 1 year of age. The genetic etiology is autosomal-dominant inheritance with highly variable expression. The syndrome is noted to be secondary to a mutation of the type 2 collagen gene, *COL2A1*, which is located on a chromosome 12q13.11-q13.3.³²



FIGURE 1-5 A 5-year-old girl with Stickler syndrome and significant myopia.

VELOCARDIOFACIAL SYNDROME (SHPRINTZEN SYNDROME, SEDLACKOVA SYNDROME, DELETION 22Q11.2)

In 1978, Shprintzen et al³³ described a condition with prominent nose, retruded mandible, cardiovascular anomalies, cleft palate, and learning disabilities. As early as 1955, Sedlackova³⁴ and coworkers reported similar patients and called the condition velofacial hypoplasia. The velocardiofacial syndrome has various manifestations,³⁵ including cardiac (85%), palatal, auricular (60%), otologic (conductive hearing loss in 75%), and general intellect and developmental problems. Hypotonia and upper respiratory illnesses in infancy and childhood are frequent. Failure to thrive in infancy is present in ~25%, and ~35% manifest short stature. Learning disabilities are experienced by 100%.

Cardiac defects are present in 85% of patients, with the most common being the ventricular septal defect (65%).³⁶ Other cardiac problems include a right-sided aortic arch (35%), tetralogy of Fallot (20%), and an aberrant left subclavian artery (20%). Craniofacial manifestations include clefts of the secondary palate, which involve either an overt cleft of the palate, a submucous cleft, or a dysfunction of the palatal muscles.³⁷ This usually results in velopharyngeal insufficiency. Other common features include a prominent nose with a narrow alar base and flat nasal root. Most patients have vertical maxillary excess (85%) with a long face syndrome and mild retrusion of the mandible with microgenia (Fig. 1–6). Patients

also have conductive hearing loss (75%) and auricular deformities, learning disabilities and low IQ, and hyperextensible joints in the hands and fingers. Occasional abnormalities include abnormalities of the internal carotid artery, other types of cardiac defects not listed above, hypospadias, scoliosis, and abnormalities of the retinal vessels.³⁸

The genetic inheritance of this syndrome is autosomal dominant. Individuals affected with Shprintzen syndrome have an interstitial deletion of chromosome 22q11.21–q11.23.³⁹ Cytogenetic analysis can be performed with a fluorescent in situ hybridization (FISH) test. However, this analysis detects only 20% of the deletions in the region. It is important to note that chromosome 22q11 is in the same region that is deleted in cases of DiGeorge sequence.⁴⁰ In that many patients have parents or siblings with both DiGeorge sequence and velocardiofacial syndrome, it is believed that the two congenital disorders represent different manifestations of the same genetic defect.

VAN DER WOUDE SYNDROME (LIP PIT-CLEFT LIP/PALATE SYNDROME)

The first report of congenital sinuses of the lower lip (Fig. 1–7) in combination with cleft lip and/or cleft palate appears to be by Demarquay in 1845.⁴¹ The syndrome was then independently reported by Murray⁴² in 1860 and got its name from the report by Van der Woude⁴³ in 1954. The syndrome occurs in roughly 1 to 2% of patients with



FIGURE 1–6 Frontal (A) and lateral (B) photographs of a child with velocardiofacial syndrome exhibiting mild mandibular retrusion, microgenia, and mild vertical maxillary excess. This patient also has a broad and flat nasal root.



FIGURE 1-7 Child with Van der Woude syndrome and congenital sinuses of the lower lip.

facial clefts or ~1:35,000 to 1:100,000 in the Caucasian population. The common abnormalities include cleft lip with or without cleft palate, cleft palate alone, cleft uvula, and lower lip pits, which are present in 80% of patients (Fig. 1–8). Patients can also have hypodontia and missing central and lateral incisors. The lower lip pits represent small accessory salivary glands.^{44–46}

The inheritance of the etiology syndrome is autosomal dominant. The responsible gene for Van der Woude syndrome has been mapped to the long arm of chromosome 1 at q32–41.⁴⁷ Another deletion of 2q34–q36 may also be responsible for this syndrome.

OROFACIODIGITAL SYNDROME

Since the first description by Mohr⁴⁸ in 1941, many cases of various types of orofacioidigital (OFD) syndrome have been described. Nine different specific syndromes have been delineated. The syndromes consist of oral frenula



FIGURE 1-8 South American patient with previously repaired bilateral cleft lip, Van der Woude syndrome, and obvious large congenital lower lip pits.

TABLE 1-6 COMMON ABNORMALITIES OF OROFACIODIGITAL SYNDROME TYPE I

<i>Common Abnormalities: Oral, Facial, Digital, Scalp, Central Nervous System, Cranium, Renal</i>
Oral: Multiple and/or hyperplastic frenula between the buccal mucous membrane and alveolar ridge. Median cleft lip. Lobated/bifid tongue with nodules. Cleft of alveolar ridge (at area of lateral incisors, which may be missing). Cleft palate. Dental caries and anomalous anterior teeth.
Facial: Hypoplasia of alar cartilages, lateral placement of inner canthi. Milia of ears and upper face in infancy.
Digital: Asymmetric shortening of digits with clinodactyly, syndactyly, and/or brachydactyly of hands and unilateral polydactyly of feet.
Scalp: Dry, rough, sparse hair and dry scalp.
Central nervous system: Variable mental deficiency in ~57%, with average IQ of 70. Brain malformation, including absence of corpus callosum and heterotopia of gray matter, in ~20% of patients.
Cranium: Increased naso-sella-basion angle at base of cranium.
Renal: Adult polycystic kidney disease.
<i>Occasional Abnormalities: Oral, Facial, Skeletal, Central Nervous System, Hair, Skin</i>
Oral: Enamel hypoplasia, supernumerary teeth, hamartoma of tongue, fistula in lower lip. Choanal atresia.
Facial: Frontal bossing. Hypoplastic mandibular ramus and zygoma.
Skeletal: Nonprogressive metaphyseal rarefaction.
Central nervous system: Trembling, hydrocephalus, seizures, berry aneurysm.
Hair: Alopecia.
Skin: Granular seborrheic skin.

and oral clefts, hypoplasia of the nasal ala, conductive hearing loss, and multiple digital problems. The major abnormalities of OFD syndrome type 1 are listed in Table 1–6. OFD syndrome type 1 was first described by Papillon-Leage and Psaume⁴⁹ in 1954. Approximately 50% of patients have mental deficiency. Many patients do poorly in early infancy with as many as one third of these dying in early childhood. The etiology of OFD syndrome type 1 is X-linked dominant with a vast majority of affected males dying. OFD syndrome type 2 (Mohr syndrome) consists of cleft tongue (Fig. 1–9), conductive hearing loss, and partial reduplication of hallux. The etiology of this syndrome (type 2) is autosomal recessive. These patients have normal intelligence.

OCULO-AURICULO-VERTEBRAL SPECTRUM (FIRST AND SECOND BRANCHIAL ARCH SYNDROME, FACIO-AURICULO-VERTEBRAL SPECTRUM, HEMIFACIAL MICROSOMIA, GOLDENHAR SYNDROME)

The oculo-auriculo-vertebral (OAV) spectrum, often called Goldenhar syndrome,⁵⁰ represents abnormalities in morphogenesis of the first and second branchial



FIGURE 1-9 Close-up view of a patient with orofacial digital syndrome and lateral clefting of the tongue.

arches.⁵¹ These defects are sometimes accompanied by vertebral or ocular anomalies. When accompanied by epibulbar dermoids (Fig. 1-10), this spectrum is designated as the Goldenhar syndrome. When the abnormality is primarily unilateral, the OAV spectrum is termed hemifacial microsomia (Fig. 1-11).⁵² The frequency of occurrence of the OAV spectrum is estimated to be 1 in 3000 to 1 in 5000 with a slight (3:2) male predominance.

The OAV spectrum affects auricular, oral, and mandibular growth.⁵³ Although bilateral involvement is common, frequently there is more severe expression of

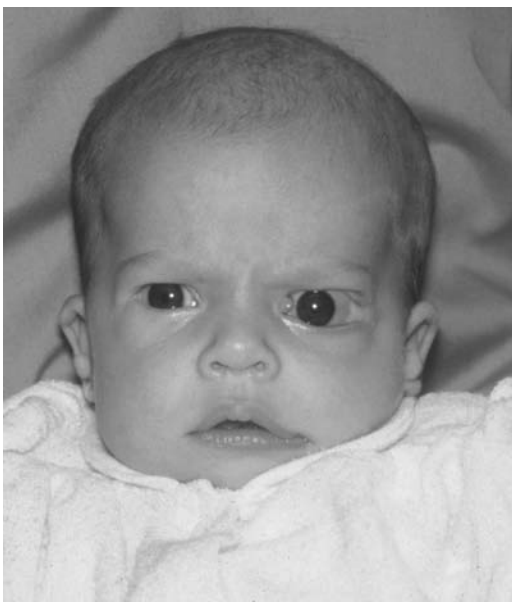


FIGURE 1-10 A 5-month-old with oculo-auriculo-vertebral (OAV) spectrum exhibiting colobomas of the upper and lower eye lids, epibulbar dermoids of the left lateral canthus, macrostomia, malformed auricles, and skin tags of the face. The patient also has facial asymmetry and hemifacial microsomia.



FIGURE 1-11 An 11-year-old girl with obvious facial asymmetry, hemifacial microsomia, and a clear occlusal cant.

the disorder on one side, giving rise to significant facial asymmetry. The common abnormalities of the OAV spectrum are noted in Table 1-7. The occasional abnormalities of the spectrum are noted in Table 1-8.⁵⁴

Most cases of OAV spectrum are sporadic in etiology. However, familial instances can be observed, suggesting an autosomal-dominant inheritance pattern in some families. Within a given family, manifestations of the spectrum vary from severe involvement to simple auricular deformities or preauricular skin tags (Fig. 1-12). There is a 3:2 predilection for right-sided ear involvement.

TABLE 1-7 COMMON ABNORMALITIES OF OCULO-AURICULO-VERTEBRAL (OAV) SPECTRUM: VARIABLE COMBINATIONS OF THE FOLLOWING, TENDING TO BE ASYMMETRIC AND 70% UNILATERAL

Facial: Hypoplasia of malar, maxillary, and/or mandibular region, especially ramus and condyle of mandible and temporomandibular joint. Lateral cleft-like extension of corner of mouth (macrostomia). Hypoplasia of facial musculature. Hypoplasia of depressor anguli oris. Ear: Microtia, accessory preauricular tags and/or pits, most commonly in a line from the tragus to the corner of the mouth. Middle ear anomaly with variable deafness. Oral: Diminished to absent parotid secretion. Anomalies in function or structure of tongue. Malfunction of soft palate. Vertebral: Hemivertebrae or hypoplasia of vertebrae, most commonly cervical but may also be thoracic or lumbar.
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TABLE 1-8 OCCASIONAL ABNORMALITIES OF OAV SPECTRUM

Eye: Epibulbar dermoid, lipodermoid, notch in upper lid, strabismus, microphthalmia
Ear: Inner ear defect with deafness
Oral: Cleft lip, cleft palate
Cardiac: Ventricular septal defect, patent ductus arteriosus, tetralogy of Fallot, and coarctation of aorta, in decreasing order
Genitourinary: Ectopic and/or fused kidneys, renal agenesis, vesicoureteral reflux, ureteropelvic junction obstruction, ureteral duplication, and multicystic dysplastic kidney
Other: Mental deficiency (IQ below 85 in 13%), branchial cleft remnants in anterior-lateral neck, laryngeal anomaly, hypoplasia to aplasia of lung, hydrocephalus, Arnold-Chiari malformation, occipital encephalocele, agenesis of corpus callosum, calcification of falx cerebri, hypoplasia of septum pellucidum, intracranial dermoid cyst, lipoma in corpus callosum, radial and/or rib anomalies, prenatal growth deficiency, low scalp hairline

The variability of OAV spectrum is significant. Some patients have an extensive range of anomalies, whereas others have only a single minor problem, such as a dysplastic ear (Fig. 1-13) or a small amount of facial asymmetry. Extensive family histories should be obtained for auricular and ocular anomalies, vertebral and skeletal problems, and cleft lip or cleft palate. Approximately 7% of reported patients have a cleft lip or cleft palate. Other features include mental deficiency (10%), vertebral abnormalities (40–60%), cardiovascular anomalies



FIGURE 1-12 Patient with OAV spectrum, significant clefting of the lateral oral commissure, and multiple preauricular and facial skin tags.



FIGURE 1-13 Patient with OAV spectrum and significant dysplasia of the ear.

(45–55%), and a variety of other central nervous system anomalies. Most patients are of normal intelligence, although mental deficiency can occur. Many patients undergo cosmetic or reconstructive surgery to correct one or more of the auricular, ocular, or facial skeletal problems.

OROFACIAL CLEFTING

Facial clefting represents the most common developmental abnormality of the face. There is great variability in the degree of cleft formation, with minimal involvement manifesting as a bifid uvula, microform clefts of the lip with minor indentations, lateral upper lip fistula, and submucous palatal clefts. Severe manifestations of facial clefting can also occur and include bilateral complete clefts of the lip and palate or lateral facial clefts, which involve the maxilla, zygoma, and orbit. The degree of clefting of the lip, palate, nose, and remainder of the face is related to the amount of embryologic insult. To better understand facial clefts and their related syndromes, the embryologic, epidemiologic, and genetic aspects of isolated cleft lip and cleft palate are reviewed in the following subsections.

EMBRYOLOGY OF THE LIP AND PALATE

The critical period in the formation of the face is the embryonic period. During the first 4 to 12 weeks of embryogenesis, most developmental abnormalities occur. Normal development of the lip and palate occurs

during the first 12 weeks of intrauterine life. The midportion of the face develops anterior to the forebrain by the differentiation of the broad midline frontonasal prominence (Fig. 1–14). The primary palate forms at approximately 4 to 6 weeks, and forms the initial separation between the oral and nasal cavities. The primary palate, or median palatine process, is formed by the fusion of the paired median nasal prominence (MNP). Fusion of the paired MNP gives rise to the central upper lip, the central maxillary alveolar arch and associated lateral and central incisors, and the hard palate anterior to the incisive foramen.^{55,56} Development of the primary palate (anterior to the incisive foramen) is distinct embryologically from normal formation of the secondary palate (posterior to the incisive foramen).

The paired median nasal processes coalesce during the sixth week and eventually form the premaxilla, philtrum of the upper lip, columella, and nasal tip (Fig. 1–15). The lateral elements of the upper lip (from the philtral column laterally) are derived from the paired maxillary processes. The cheek, maxilla, zygoma, and secondary palate are also formed from the maxillary processes.

The upper lip, therefore, is formed from both the median nasal and maxillary processes.⁵⁷

The secondary palate begins developing at approximately 8 weeks of gestation, after development of the primary palate is completed. Formation of the secondary palate occurs by inferior and medial growth and migration of the palatal shelves (the medial projections of the maxillary processes). As the palatal shelves displace inferiorly (similar to a drawbridge), the developing nasal cavities expand laterally and inferiorly.

The paired palatal shelves are initially separated by the developing tongue. Growth of the mandible with associated anterior movement of the tongue allows the palatal shelves to migrate inferiorly and assume a more horizontal orientation. If fetal development and migration of the mandible does not proceed normally, the paired palatal shelves cannot migrate inferiorly and medially. Lack of contact of these shelves creates palatal clefting. This malformation can result in the Pierre Robin sequence (micrognathia, relative macroglossia, and U-shaped cleft palate).⁵⁸ The normal sequence of palatal formation begins when the palatal shelves and nasal

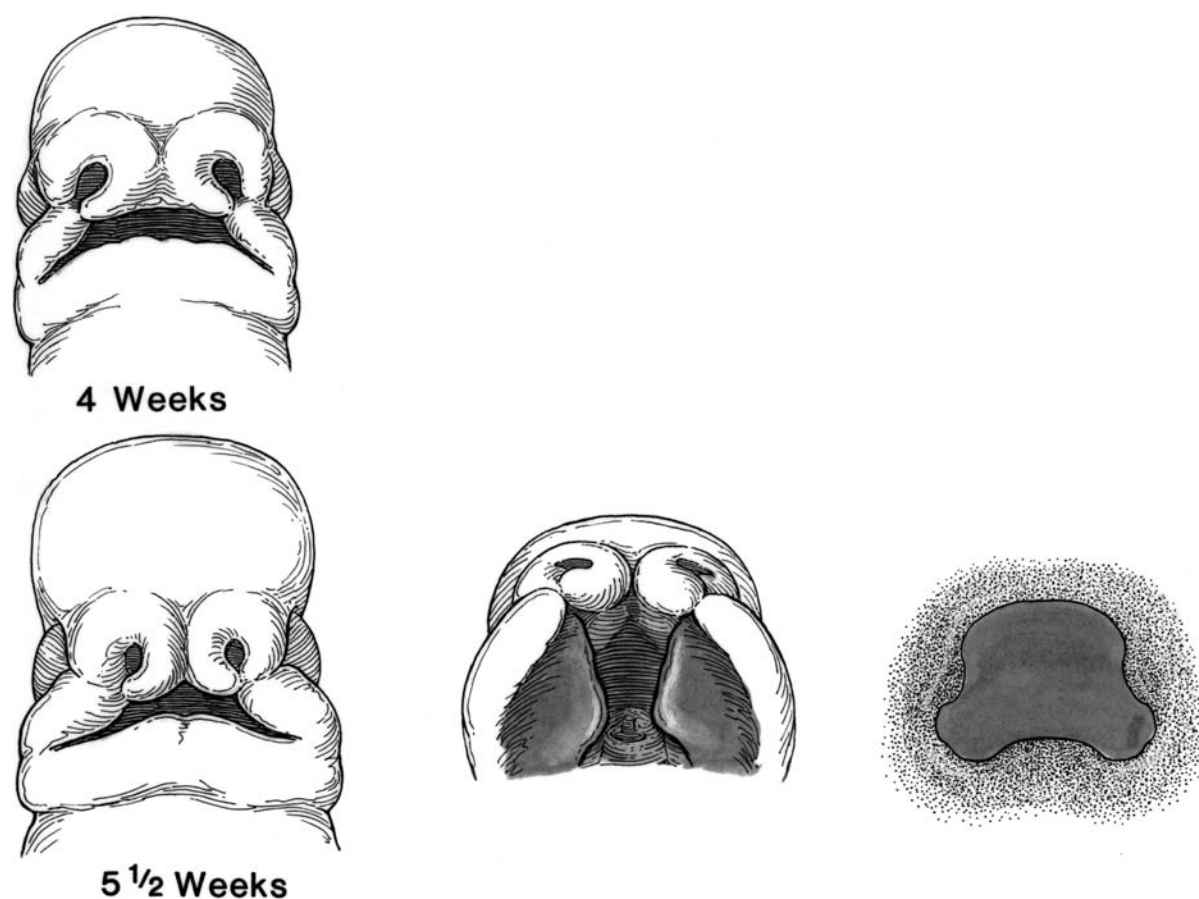


FIGURE 1–14 Schematic diagram of the development of the lip and palate at 4 and 5½ weeks of gestational age. The primary palate is forming at about 4 to 6 weeks by fusion of the paired median nasal prominences. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

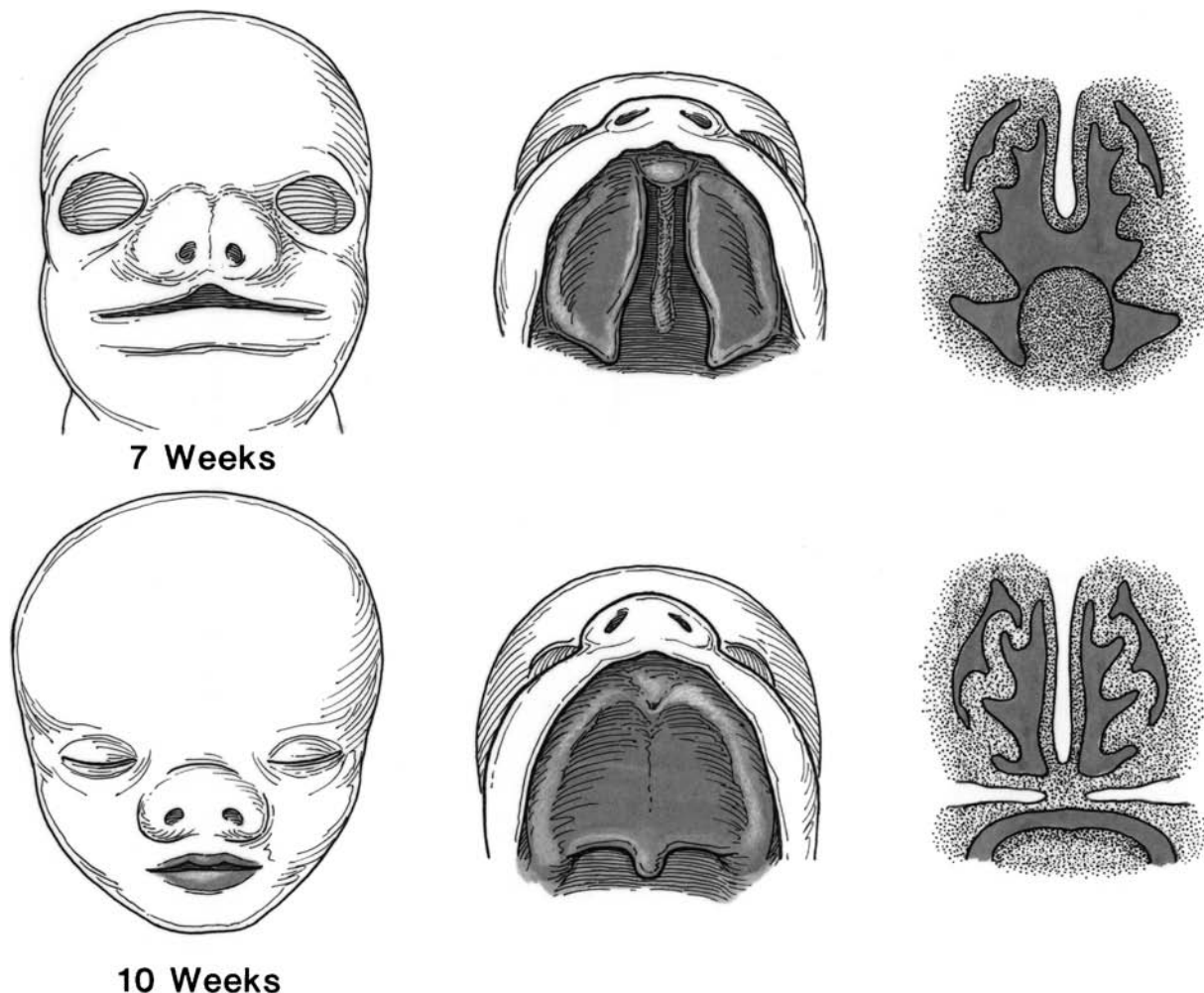


FIGURE 1-15 Schematic diagram of the embryo at age 7 and 10 weeks during which time the secondary palate forms in an anterior-to-posterior fusion process beginning anteriorly at the incisive foramen. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

septum contact each other, and proceeds in an anterior-to-posterior direction beginning at the incisive foramen. Palatal closure first occurs at the incisive foramen at approximately 8 weeks of gestation and is usually completed through the uvula by 12 weeks. The degree of clefting of the secondary palate is related to many factors including when in fetal development the fusion process is interrupted. Therefore, the palatal abnormality associated with the Pierre Robin sequence can be only a bifid uvula, a submucous soft palate cleft, or a complete cleft of the secondary palate.⁵⁹

EPIDEMIOLOGY OF CLEFT LIP AND PALATE

Cleft Lip with or Without Cleft Palate

For the purposes of the epidemiology and genetics of facial clefting, congenital clefting can be divided into (1) cleft lip with or without cleft palate and (2) isolated cleft

palate. The incidence of cleft lip with or without cleft palate is ~1/1000 white births.^{60,61} The relative incidence varies significantly according to race, with American Indians having the highest incidence (3.6/1000)^{62,63} compared with African-American births (0.3/1000).^{64,65} The incidence is also high in Japanese⁶⁶ (~2.1/1000) and Chinese (1.7/1000) births.^{67,68}

Isolated cleft lip without cleft palate is typically unilateral (80%),⁶⁹ more commonly located on the left side (70%),⁷⁰ and usually present in boys (60%). However, not all races have similar distributions of sex and sidedness. Ten percent of cleft lips are incomplete. Approximately 85% of cases of bilateral cleft lip and 70% of unilateral cleft lip are associated with cleft palate.

Isolated Cleft Palate

Isolated cleft palate appears to be a separate entity from cleft lip with or without cleft palate. The siblings of

patients with cleft lip with or without cleft palate have an increased frequency of this anomaly, but these siblings do not have an increased incidence of isolated cleft palate.⁷¹ The incidence of isolated cleft palate in white births is 0.5/1000.⁷² Isolated palatal clefting is more common in girls (2:1), but the ratio becomes closer to 1:1 when clefts of only the soft palate are considered.⁷³ Submucous clefts of the soft palate are caused by incomplete union of the fusing palatal muscles.⁷⁴ The incidence of submucosal soft palate clefts is 1/1200 to 1/2000 white births with greater than 50% of these patients being boys.^{75,76} The overall incidence of cleft uvula (1/80 white births) is expectedly much higher than the incidence of cleft palate (1/2500 births).⁷⁷ The sex preponderance for clefting of the uvula is 1:1.⁷⁸ As opposed to complete and submucosal clefts, clefts of the uvula tend to vary with race, with American Indians having the highest incidence at 1:9 to 1:14 births.^{79,80}

Lateral and oblique clefts as classified by Tessier and occur uncommonly. It is estimated that lateral facial clefts represent 0.25% of cleft births or 1 in 50,000 to 1 in 175,000 live births.^{81,82}

Genetics of Facial Clefting

The etiology of facial clefting is multifactorial. Currently, there is no true consensus as to the genetic cause of facial clefting. The cause is likely a heterogeneous process that results from a variety of factors including major genes (autosomal dominant with incomplete penetrance, codominant, and autosomal recessive), minor genes, environmental insults, and developmental threshold. It is clear that the recurrence risks for facial clefting do not correspond to any simple mendelian pattern of inheritance. This fact is supported by various studies on twins who have facial clefts. Twin studies have identified the relative roles of both genetic and nongenetic factors on cleft production. Gorlin et al^{15,83} have tabulated twin studies in 1988 (Table 1–9) in twins with cleft lip with or without cleft palate; concordance is far greater for monozygotic (36%) than for dizygotic twins (4.7%). The fact that the concordance in monozygotic twins (36%) is not 100%

suggests that there are factors other than genetics involved in clefting. In twins with isolated cleft palate, the difference in concordance between monozygotic (22%) twins and dizygotic (4.6%) twins is not as great. This suggests a stronger genetic basis for cleft lip with or without cleft palate than the genetic basis for isolated cleft palate. The concordance of 4.6% for dizygotic twins is greater than that for nontwin siblings, which implies that maternal factors are present in causing clefting.

If genetics were the only basis for clefting, monozygotic twins would have a 100% concordance, whereas dizygotic twins who share up to 50% of their genes would have a higher concordance than is demonstrated in these twin studies. The largest twin study demonstrated concordance for monozygotic twins for cleft palate of only 50% and in dizygotic twins of 0%. Conclusions from all twin studies indicate that both genetic and environmental factors influence the development of facial clefting, and there seems to be a stronger genetic influence on cleft lip with or without cleft palate than there is on cleft palate alone.

Environmental factors have been proven to have a direct effect on the incidence of clefting. Phenytoin, retinoic acid derivatives, and folic acid antagonists have all been shown to have a direct relation with clefting. Cigarette smoking with its relative fetal hypoxia and first-trimester alcohol use have also been implicated as factors that increase the risk of clefting. Recent data indicate that folic acid supplements taken by mothers during the embryonic stage of development can reduce the incidence of nonsyndromic facial clefting.

The final genetic point is that facial clefting occurs within syndromes and outside of syndromes. A syndrome must include a cognitive or structural abnormality that is distinct from the cleft; the abnormalities are thought to be pathologically related; 30 to 65% of facial clefts are related to a named syndrome. Cleft lip with or without cleft palate is associated with syndromes 14% of the time, and cleft palate alone is associated with a syndrome nearly 55% of the time. There are more than 300 named syndromes that include facial clefting.

TABLE 1–9 CONCORDANCE IN FACIAL CLEFTS-TWIN STUDIES

	<i>Monozygotic twins</i>		<i>Dizygotic twins</i>	
	<i>CL(P), n = 84</i>	<i>CP, n = 27</i>	<i>CL(P), n = 191</i>	<i>CP, n = 44</i>
Concordance (<i>n</i>)	34	6	9	2
%	36.2	22.2	4.7	4.6

CL(P), cleft lip with or without cleft palate; CP, cleft palate.

Based on Gorlin et al together with cases of Blake and Wreakers, Schweckendiek, Shields et al, Czeizel, Davies and Thompson, Tolarová (personal communication, 1988), and other authors. (From Gorlin RJ, Cohen M, Levin LS. *Syndromes of the Head and Neck*, 3rd ed. New York: Oxford University Press, 1990.)

TABLE 1-10 COMPARATIVE EMPIRIC RISKS FOR CLEFT LIP-PALATE AND CLEFT PALATE

	CL(P)		CP	
	% Proband		% Proband	
Relative	Male	Female	Male	Female
Brother	6.7	6.8	1.8	2.8
Sister	2.8	4.4	3.7	1.7
Son	6.7	2.4	11.5	6.0
Daughter	4.0	8.7	5.6	17.2

Modified from Melnick M et al. *Clinical Dysmorphology of Oral-Facial Structures*. Boston: John Wright, 1982. (From Lin KY, Ogle RC, Jane JA. *Craniofacial Surgery*. Philadelphia: WB Saunders, 2002.)

Recurrence Risks for Facial Clefting

The relative recurrence risks for cleft lip with or without cleft palate and for isolated cleft palate for an affected parent or in the case of normal parents who have an affected child have been determined in numerous studies. For cleft lip with or without cleft palate and for isolated cleft palate, if the proband has no other affected first- or second-degree relatives, the empiric risk is 3 to 5%. However, if the affected child has other affected first-degree relatives, the risk to unborn siblings rises to 10 to 20%.^{84,85} In the uncommon case of both parents being affected with facial clefting, the empiric risk data range between 25 and 50% (Table 1-10). For her Ph.D. thesis, Tolarová calculated the relative recurrence risks for unborn offspring with mother, father and affected sibs (Table 1-11).

Classification of Clefts

The embryologic development of the lip and palate serves as a natural mechanism to classify congenital

clefts. The upper lip and primary palate develop at between 4 and 8 weeks of gestation. Interruption of this development can cause clefts of the upper lip and alveolus (primary palate). Cleft lips may be unilateral or bilateral, and may be complete or incomplete. The upper lip clefting may be isolated, may be associated with clefts of the alveolus and palate, or may be associated with other malformations (syndromic clefts). Clefting of the upper lip, with or without associated palatal clefting, is caused by failure of the median nasal prominences to make contact with the lateral nasal process and the maxillary process during embryogenesis. Interruption of this embryologic process creates maldevelopment of some or all of the upper lip, the central maxillary arch, the anterior portion of the palate, and the base of the nose and nasal tip.

The degree of clefting of the upper lip, alveolus, and nose is related to the amount of the embryologic insult to the upper lip. The lip deformity ranges from a minor malformation of the normal development of the lip to a complete interruption of all layers of the lip and base of the nose. A minor malformation of the normal lip development may cause dehiscence of the orbicularis oris muscle with no overt clefting of the epidermis of the upper lip. This condition is known as a *microform cleft* of the upper lip (Fig. 1-16). A more significant interruption of the upper lip development is referred to as an *incomplete cleft lip* (Fig. 1-17). An incomplete unilateral cleft lip involves a through-and-through defect of skin, muscle, and mucosa of the lower aspect of the lip, but does not extend superiorly through the entire height of the lip. A *complete unilateral cleft lip* occurs when the defect

TABLE 1-11 RECURRENCE RISK FOR CLEFTS IN SIBS OF PROPOSITI

Affected Parent	CL(P) %	CP %
<i>Mother affected</i>		
Affected sibs		
0	2.7	2.3
1	9.9	11.2
2	18.3	21.1
<i>Father affected</i>		
Affected sibs		
0	2.3	5.0
1	9.3	14.4
2	17.6	23.9
<i>Both parents affected</i>		
Affected sibs		
0	24.0	45.0
1	31.7	51.6
2	37.6	54.5

From Tolarová M, Ph.D. Thesis, Charles University, Prague, Czechoslovakia, 1984. (From Lin KY, Ogle RC, Jane JA. *Craniofacial Surgery*. Philadelphia: WB Saunders, 2002.)



FIGURE 1-16 A 3-month-old with a left microform cleft lip. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)



FIGURE 1-17 A 3-month-old with an incomplete left cleft lip. Note the alar base asymmetry and inferior displacement of the left alar rim.

involves all tissue layers of the upper lip and extends through the entire height of the lip and floor of the nose (Fig. 1-18). A cleft of the alveolus is almost always associated with complete clefting of the upper lip.

The degree of clefting of the upper lip depends on the timing and degree of interruption of normal lip development. If lip development of both sides is disrupted, a bilateral cleft lip results. In the incomplete bilateral cleft lip, there is usually some skeletal continuity between the lateral maxillary processes and the central premaxilla (Fig. 1-19). For this reason, there is often little or no protrusion of the premaxilla in incomplete bilateral cleft lips. In the complete bilateral cleft lip deformity, the central premaxilla is totally detached from each lateral maxillary process (Fig. 1-20). This may result in a “locked out” premaxilla (Fig. 1-21).



FIGURE 1-18 (A) A 6-week-old with a complete cleft of the right lip and palate. (B) Basal view of the same child with complete clefting of the lip and palate. Note the significant alar base asymmetry and the deviation of the columellar to the noncleft side.



FIGURE 1-19 Basal view of a child with an incomplete bilateral cleft lip and palate. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)



FIGURE 1-20 A 4-month-old boy with bilateral symmetric cleft lip and palate.

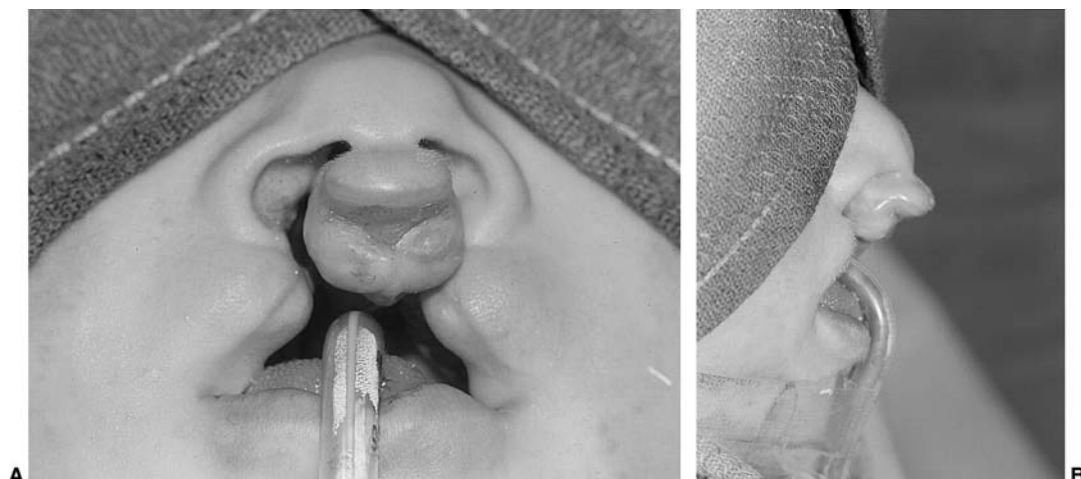


FIGURE 1-21 (A) Frontal view. (B) Lateral view. A 14-year-old boy with unrepaired bilateral cleft lip and cleft palate. Note the maxillary constriction and “locked out” premaxilla. The significant bilateral cleft lip results in a short columella and poor projection of the nasal tip. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

The unilateral or bilateral cleft lip deformity may be isolated or associated with clefts of the alveolus or palate. Because a greater interruption of lip development is required to create a bilateral cleft lip deformity, the bilateral lip deformity is more likely to be associated with clefting of the secondary palate than is the unilateral cleft lip deformity.

The primary palate is formed at between 4 and 8 week’s gestation simultaneously with the development of the upper lip and central maxillary alveolar ridge. The secondary palate is composed of the horizontal plate of the maxilla and palatine bone. The secondary palate fuses in the anterior-to-posterior direction at between weeks 8 and 12 embryologically. Interruption of the normal fusion of the secondary palate causes various degrees of palatal clefting.

Clefts of the secondary palate can be variable in expression, depending on the timing and degree of interruption of palatal development. The most common condition and the smallest expression of clefting of the soft palate is the *bifid uvula* (Fig. 1-22). This common deformity occurs when there is a lack of normal fusion of the uvula. A *submucous cleft of the soft palate* occurs when there is dehiscence of the muscles of the soft palate (Fig. 1-23). In this condition, the palatal mucosa is intact, but there is incomplete development of the underlined palatal musculature. A submucous cleft palate often requires speech therapy and sometimes requires surgical repair. Full-thickness clefting of the soft palate can manifest with either an incomplete or complete secondary palatal cleft (Fig. 1-24). The incomplete secondary cleft occurs through the entire soft palate and into a portion of the hard palate. Complete clefting of the secondary palate may result from total interruption of the normal formation of the palate posterior to the incisive foramen.⁸⁶



FIGURE 1-22 Intraoral view of a patient with an isolated bifid uvula.



FIGURE 1-23 Intraoral view of a patient with a submucous cleft of the soft palate. Note the zona pellucida indicating the dehiscence of the soft palatal musculature.

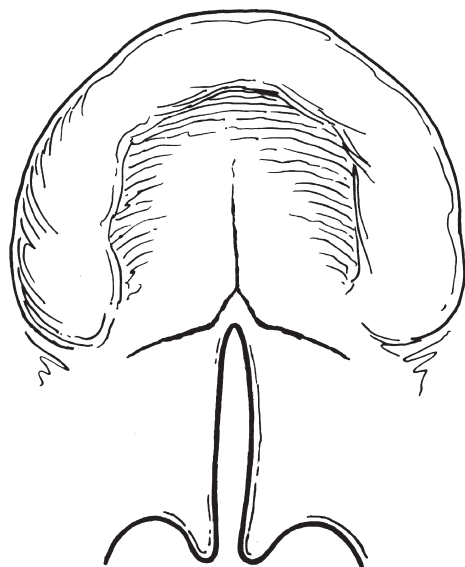


FIGURE 1-24 Schematic diagram of a cleft of the soft palate. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

Clefts of the secondary palate may be associated with complete cleft lips and are termed *complete clefts of the lip and palate*. Complete cleft lip and palate may be unilateral or bilateral. The complete unilateral cleft lip and palate usually involves attachment of the vomer to the maxillary palatal shelf of the noncleft side (Fig. 1-25). Complete bilateral clefts of the lip and palate usually

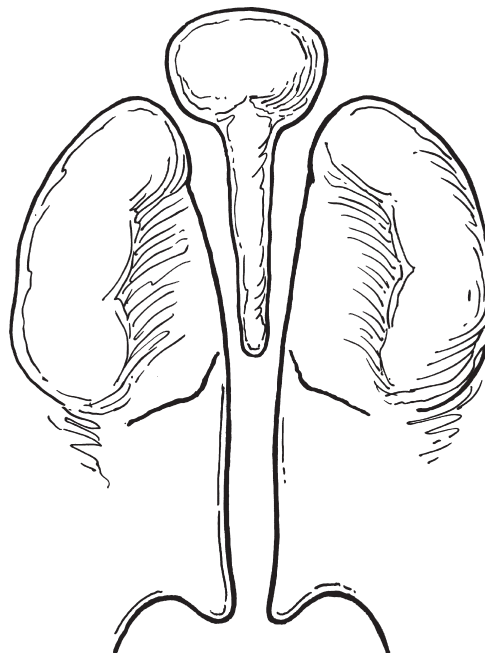


FIGURE 1-26 Schematic diagram of a complete bilateral cleft palate. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

have the central vomer and premaxilla detached from the two lateral palatal shelves (Fig. 1-26). In all cases, clefting of the lip and palate is variable in expression and typically follows known embryologic patterns.

TIMING AND PHILOSOPHY OF CLEFT REPAIR

The decision to repair a cleft lip or palate deformity is based on a variety of factors: speech development, facial growth, psychological impact on the child and family, and safety to undergo anesthesia. The timing of repair of various cleft deformities is outlined in Table 1-12.⁸⁷ In patients with palatal clefting with or without clefts of the lip, tympanostomy tube placement is performed at age 3 to 6 months. This surgery is performed at an early age to (1) aerate the middle ear, (2) decrease conductive hearing loss, and (3) minimize the likelihood of chronic ear disease. In patients with cleft lip and palate, tympanostomy tube placement is performed at the same time as cleft lip repair. In these patients, surgery is performed at approximately 3 months of age and includes (1) cleft lip repair, (2) tympanostomy tube placement, and (3) closure of the floor of the nose and nasal rhinoplasty (when indicated). Cleft palate repair is performed prior to the initial development of speech. This is usually performed at 9 to 15 months of age. Long-acting tympanostomy tubes are placed at the time of palatoplasty.

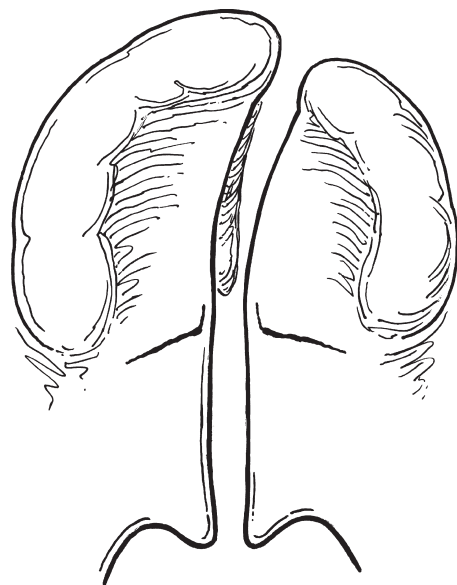


FIGURE 1-25 Schematic diagram of a complete unilateral cleft of the hard and soft palate. (From Papell ID. *Facial Plastic and Reconstructive Surgery*. 2nd Ed. New York: Thieme 2002. Used with permission.)

TABLE 1-12 TIMING OF CLEFT REPAIRS

Cleft Procedure	Age at Repair
Cleft lip repair	3 months
Tip rhinoplasty	
Tympanostomy tubes	
Palatoplasty	9–18 months
T-tube placement	
Speech evaluation	3–4 years
Velopharyngeal insufficiency workup and surgery (if necessary)	4–6 years
Alveolar bone grafting	9–11 years
Nasal reconstruction	12–18 years
Orthognathic surgery (if necessary)	At completion of mandibular growth (>16 years)

After cleft palate repair, patients are monitored carefully by the cleft and craniofacial team. Speech development is evaluated carefully beginning at 2 years of age. If velopharyngeal dysfunction (VPD) is identified, a VPD workup, including nasopharyngoscopy and video fluoroscopy, is performed. If the degree of VPD is significant, speech therapy is undertaken at approximately 3 years of age. If the patient does not respond to aggressive speech therapy, surgical treatment to correct the VPD is performed at between 4 and 6 years of age.

Other surgical treatments for cleft deformities include alveolar bone grafting at 9 to 11 years of age, internal and external nasal reconstruction (cleft septorhinoplasty) at 12 to 18 years of age, and orthognathic surgery after growth of the facial skeleton is complete. The need for these interventions is related to the initial deformity as well as the growth and development of the patient.

THE UNILATERAL CLEFT LIP DEFORMITY: PATHOLOGIC ANATOMY

A unilateral cleft of the upper lip involves alterations in all layers of the lip, including skin, muscle, mucosa, and underlying skeletal framework. The external form of the defect is determined by the extent of the underlying muscular and skeletal deformity. Subcutaneous (microform) cleft lip involves partial or total clefting of the upper lip musculature. Partial (incomplete) cleft lip involves skin, muscle, and mucosa, but may spare the underlying skeletal structures. Complete unilateral lip deformities involve all tissue layers.

The principal muscle of the lips is the orbicularis oris muscle (Fig. 1-27). The fibers of this muscle encircle the oral orifice within the substance of the lips.⁸⁸ The orbicularis oris muscle consists anatomically of two parts: the superficial and the deep layers. This muscle is not a true sphincter, with the superficial and deep components arising as separate muscles from the modiolus at each oral commissure.⁸⁹

In the unilateral cleft lip deformity, there is discontinuity of the orbicularis oris muscle in the region of the cleft (Fig. 1-28). The muscles of the unilateral cleft lip have two distinct differences when compared with normally developed lip musculature. First, the muscles are hypoplastic in the region of the cleft. Second, the muscles cannot cross the cleft gap and are prevented from attaching to their normal sites and have to find substitute insertions. Although it is obvious that no muscle crosses the cleft gap in complete lip clefting, the skin bridge in incomplete clefts has also been found to contain no functional musculature. Muscle dissections by Fara et al⁹⁰ on stillborn babies with incomplete clefts confirm that the muscles in unilateral cleft lips are more hypoplastic on the medial side than on the lateral side of the cleft.



FIGURE 1-27 Schematic diagram of the orbicularis oris muscles as they relate to the other facial musculature. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)



FIGURE 1-28 Schematic diagram of the orbicularis oris muscles associated with a unilateral cleft lip deformity. The muscles surrounding the upper lip cleft substitute with unnatural insertions along the cleft margin. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

Additionally, these dissections reveal that the upper lip muscles in incomplete clefts did not cross the cleft gap unless the skin bridge was at least one-third the height of the lip. Even if the orbicularis oris muscle is present in the skin bridging the incomplete cleft, the orientation of the musculature is abnormal.

The major vascular supply to the lips and nose arises from the facial artery, which is a branch of the external carotid artery. The facial artery gives rise to the superior and inferior labial arteries at each oral commissure. The paired superior labial arteries anastomose in the midline of the upper lip, and the two inferior labial arteries similarly anastomose in the lower lip. In the unilateral cleft lip deformity, the aberrant vascular supply parallels the findings of the unilateral cleft lip musculature (Fig. 1-29). As with the musculature, the blood supply on the lateral aspect of the cleft is better developed than is the vasculature on the medial side. In the incomplete cleft lip

deformity, a terminal branch of the superior labial artery crosses the epithelial skin bridge.

UNILATERAL CLEFT LIP REPAIR

Many techniques have been described over the years for repair of the unilateral cleft lip deformity. Ambroise Paré⁹¹ repaired the unilateral cleft by freshening the cleft edges and skewering the two sides of the cleft with a long needle. The needle was then wrapped with thread in a figure-of-eight fashion. Rose⁹² and Thompson⁹³ described modifications of straight-line closures for repair of the unilateral cleft lip deformity. All of the straight-line techniques close the cleft defect adequately, but often resulted in vertical scar contracture and notching of the upper lip. Wide complete unilateral cleft lips are also difficult to repair by the straight-line method. In the mid-20th century, various geometric closure techniques were proposed

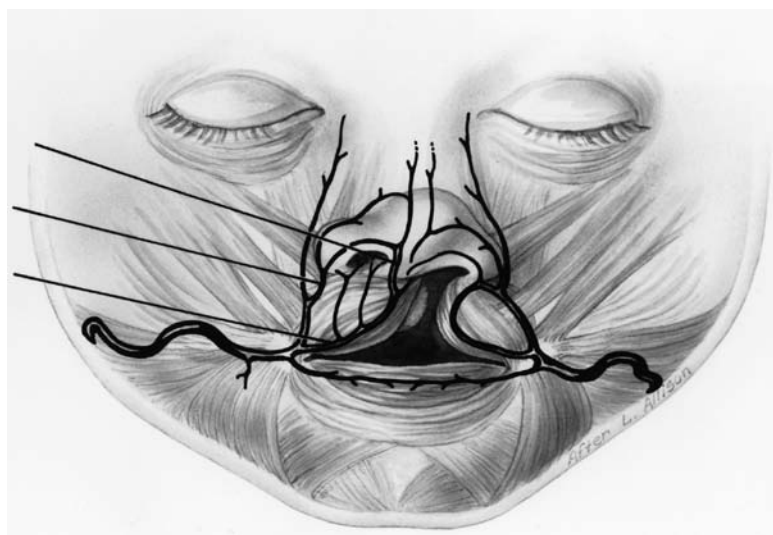


FIGURE 1-29 Schematic diagram of the aberrant vascular supply of the unilateral cleft lip. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

for repairing the unilateral cleft lip. Geometrical techniques, such as modified Z-plasties, quadrangular flaps, and triangular flaps, were designed to decrease the amount of lip shortening that occurred with cleft lip repair and to improve orbicularis oris muscle realignment and function.^{92,94,95} The triangular flap designed by Tennison and the quadrangular flap of Le Mesurier⁹⁶ are reliable, consistent methods for decreasing vertical lip contraction in the unilateral cleft lip repair.

The primary advantage of geometric cleft lip repair techniques is that they provide a reproducible method to repair the lip. Exact measurements can be made with calipers to ensure reliable tension-free closure of the lip. The basic disadvantage of geometric designs is that the incisions always violate the curved philtral column on the noncleft side, creating a scar that crosses boundaries of known anatomic subunits. In addition, geometric repairs require exacting presurgical measurement and lack flexibility during surgical applications. In 1957, D. Ralph Millard⁹⁷ incorporated aspects of multiple previously described repairs and developed the rotation-advancement flap technique for repair of the unilateral cleft lip deformity. This method maximizes flexibility for the surgery while minimizing the amount of normal lip tissue discarded. This method is the most commonly used technique today for unilateral cleft lip repair. The advantages and disadvantages of the Millard rotation-advancement flap technique are listed in Table 1–13.⁹⁸

ROTATION-ADVANCEMENT REPAIR OF THE UNILATERAL CLEFT LIP DEFORMITY

The primary goals of unilateral cleft lip repair are to reconstruct normal lip anatomy and to restore lip

TABLE 1–13 ADVANTAGES AND DISADVANTAGES OF THE MILLARD ROTATION-ADVANCEMENT REPAIR

<i>Advantages</i>	<i>Disadvantages</i>
Flexible	Requires experienced surgeon
Minimal tissue discarded	Possible excess tension
Good nasal access	Extensive undermining required
Camouflaged suture line	Vertical scar contracture
	Tendency to small nostril

function. Other goals include closure of the nasal floor, correction of nasal tip asymmetry, and narrowing of the alveolar cleft.⁹⁸ The rotation-advancement flap technique designs two major full-thickness flaps that can be approximated to repair the cleft without notching of the lip. This design allows reconstitution and reorientation of the orbicularis oris muscles.

The main advantage of the rotation-advancement flap technique is its flexibility in application. This procedure allows continuous modifications during the design, incision, and execution of the repair. Another advantage is that the incisions are designed to place the eventual scar in the new philtral column. Most geometric flap designs, on the other hand, violate the philtral subunit.

The important reference points of the rotation-advancement flap technique (Fig. 1–30) are summarized in Table 1–14.⁹⁸ Some of these points are anatomic, whereas the others are “measured.” Several measurements may be used to maximize flap design and eventual lip aesthetics. The ultimate objectives of these measurements is to ensure that the length of the rotation flap (3 to $5 + x$ [x is the back cut at the superior extent of the rotation flap]) equals the length of the advancement flap (8 to 9) (Table 1–15).

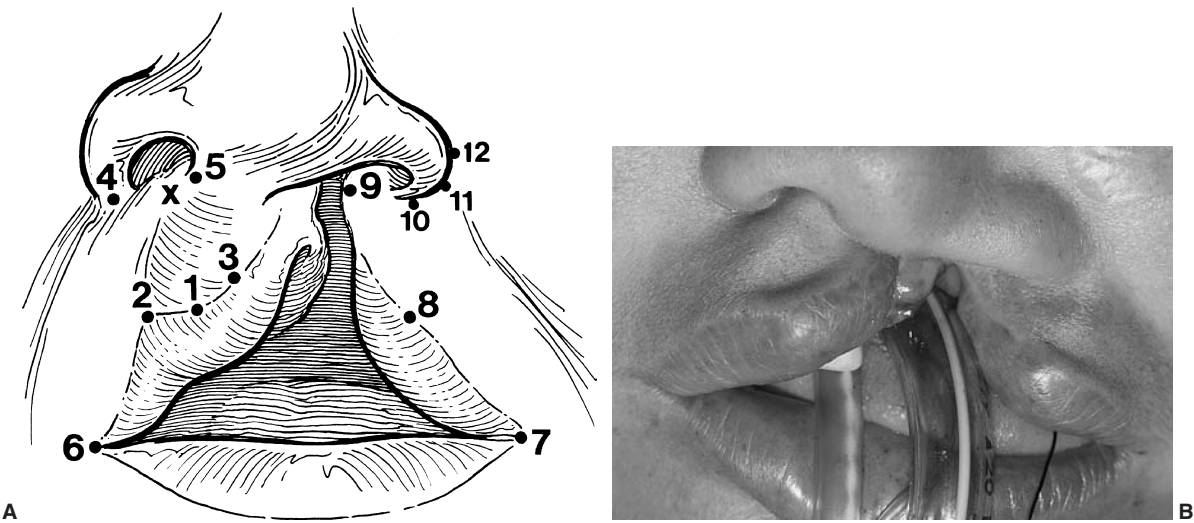


FIGURE 1–30 (A) Schematic diagram of the marked and measured points of the Millard rotation-advancement unilateral cleft lip repair (see Table 1–14). (B) A 3-month-old with left cleft lip showing the marked points for the rotation-advancement lip repair. (From Papell ID. Facial Plastic and Reconstructive Surgery, 2nd ed. New York: Thieme, 2002, with permission.)

TABLE 1-14 MILLARD ROTATION-ADVANCEMENT
TECHNIQUE: REFERENCE POINTS

1. Center (low point) of Cupid's bow: noncleft side (NCS)
2. Peak of Cupid's bow: lateral NCS
3. Peak of Cupid's bow: medial NCS
4. Alar base: NCS
5. Columellar base: NCS
- X. Back-cut point: NCS
6. Commissure: NCS
7. Commissure: cleft side NCS
8. Peak of Cupid's bow: cleft side (CS)
9. Medial tip of advancement flap: CS
10. Midpoint of alar base: CS
11. Lateral alar base: CS

TABLE 1-15 MEASUREMENTS FOR ROTATION-
ADVANCEMENT FLAP DESIGN

- 1 to 2 = 1 to 3 = 2–4 mm
- 2 to 6 = 8 to 7 = 20 mm
- 2 to 4 = 8 to 10 = 9–11 mm
- 3 to 5 + x = 8 to 9

TABLE 1-16 ROTATION-ADVANCEMENT FLAP DESIGNATION

- A: Rotation flap
 B: Advancement flap
 c: Columellar base soft tissue flap
 D: Alar rim flap
 m: Medial mucosal flap
 l: Lateral mucosal flap

The reference and premarked incisions create major full-thickness flaps A (rotation) and B (advancement), and minor flaps c (skin), m (medial mucosal), and l (lateral mucosal) (Table 1-16) (Fig. 1-31). After incising and

dissecting these lip flaps, dissection and reapproximation of the orbicularis oris muscle is performed. This closure maximizes lip function while minimizing tension across the eventual lip wound. The Millard rotation-advancement lip repair also allows active closure of the nasal floor and nasal tip rhinoplasty (Figs. 1-32 and 1-33). These procedures create improved symmetry of the nasal tip and alar base. Complete access to the nasal tip can be obtained through the standard perialar and cleft margin incisions, without creating additional nasal incisions. This allows for improved symmetry of the nasal tip and relative equalization of the alar base.

THE BILATERAL CLEFT LIP DEFORMITY: PATHOLOGIC ANATOMY

The shape and configuration of the two lateral segments of the bilateral cleft lip deformity are similar to the lateral segment of the unilateral deformity. However, the central segment of the bilateral cleft lip deformity is an entity that has no correlate in the unilateral deformity. The orbicularis oris muscle grows laterally to medially into the midportion of the lip or prolabium. The amount of muscle present in the prolabium depends on the extent of the cleft deformity. Incomplete bilateral clefts generally have a diminished amount of misdirected muscle fibers present, whereas complete bilateral clefts have no muscle present in the prolabium. In the incomplete bilateral cleft lip, there is usually some skeletal continuity and very little protrusion of the premaxilla and prolabium. The premaxilla in complete bilateral cleft lips usually protrudes more than it does in the incomplete deformity; therefore, the columella of the nose is usually shorter in the complete bilateral cleft lip deformity than it is in the incomplete bilateral deformity.

Most bilateral cleft lip deformities tend to be symmetrical. This advantage allows the cleft surgeon to create a bilaterally symmetrical lip by doing a single staged operation. This is contrasted to the unilateral cleft lip repair,

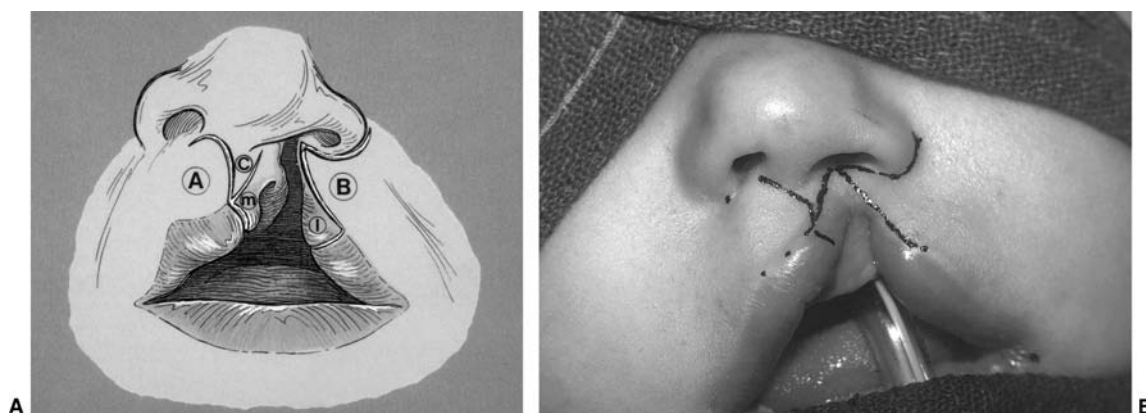


FIGURE 1-31 (A) Schematic diagram of the major and minor flaps created in the rotation advancement cleft lip repair. A, rotation flap; B, advancement flap; c, epithelial byproduct flap; m, medial mucosal flap; l, lateral mucosal flap. (B) Intraoperative photograph of a patient after marking the rotation and advancement flaps.

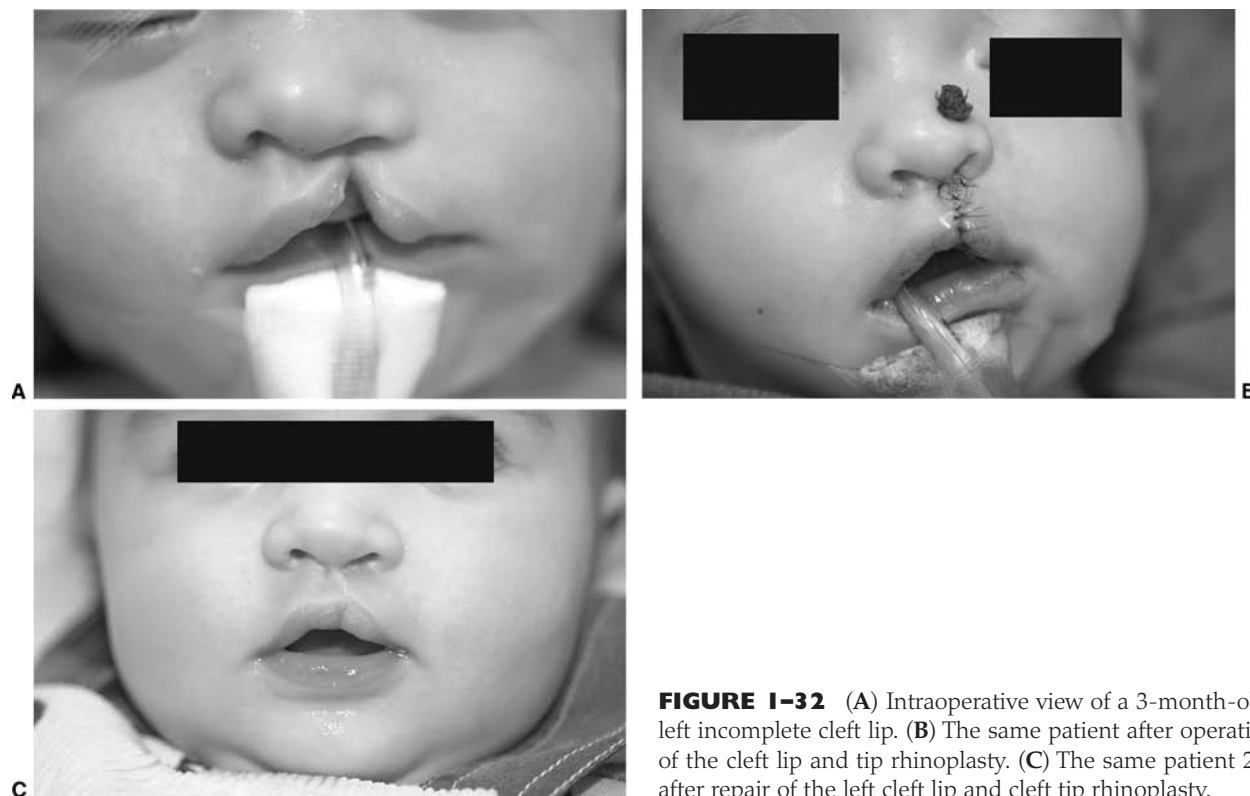


FIGURE 1-32 (A) Intraoperative view of a 3-month-old with a left incomplete cleft lip. (B) The same patient after operative repair of the cleft lip and tip rhinoplasty. (C) The same patient 2 months after repair of the left cleft lip and cleft tip rhinoplasty.



FIGURE 1-33 (A) A 2-day-old with left complete cleft lip and palate and significant alar base deformity. (B) The same patient at 10 months of age after repair of the cleft lip and tip rhinoplasty.

in which the surgeon attempts to match the abnormal cleft side to the normal, or noncleft side.

The arterial network and musculature of the lateral elements of the complete bilateral cleft lip parallel that of the lateral segment in the unilateral deformity (Fig. 1-34). The abnormal insertion of the cleft lip musculature follows the margin of the cleft.^{99,100} The arterial supply in bilateral cleft lips is characterized by an aberrant course of the superior labial artery. This artery runs superiorly along the edge of the cleft and anastomoses with the angular and lateral nasal arteries. This abnormal course is similar to that in the lateral segment of the unilateral deformity. The prolabial segment in the bilateral

complete deformity receives its blood supply from the septum, columella, and premaxilla.

BILATERAL CLEFT LIP REPAIR

The timing and technique for repair of the bilateral cleft lip deformity is related to the extent and the deformity and the philosophy of the operating surgeon. The repair can be performed after presurgical orthopedics or lip adhesion, both designed to narrow the cleft gap and to better align the cleft segments. Definitive bilateral lip repair can be performed in a single stage or performed in two separate surgical procedures.



FIGURE 1-34 Schematic diagram of the aberrant bilateral cleft lip musculature with abnormal insertion of the muscles. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

In patients with a wide complete bilateral cleft lip, alveolus, and secondary palate, a single-stage bilateral cleft lip adhesion may be indicated.¹⁰¹ This procedure converts a complete bilateral cleft lip deformity to an incomplete deformity, and allows the repair to be performed under more favorable conditions with reduced tension. Bilateral cleft lip adhesion exerts an orthopedic force on the premaxilla, which inhibits forward growth of the premaxilla. This orthopedic force retropositions the central premaxilla into an improved position in relation to the lateral lip segments.

The decision to perform a single-stage versus a two-staged lip repair is often related to the deformity and to the comfort and experience of the cleft surgeon. The two-staged technique has the advantage of allowing better vascularity to the central prolabial segment and the capability to apply the techniques of the Millard rotation-advancement repair to each side of the bilateral repair.¹⁰² However, the two-staged repair has two significant disadvantages compared with the single-stage repair. The two-staged bilateral cleft lip repair tends to create asymmetry of the lip as the first side lip closure has rapid

growth of the lip after supplying vascularity to the repaired lip. This asymmetry is difficult to correct. Additionally, the two-staged repair does not allow muscle to be advanced or cross the central prolabial segment, and can produce a secondary deformity from this lack of muscle. The single-stage bilateral cleft repair, as described by Millard in 1977, is designed to produce an intact lip with scars mimicking the philtral columns. This technique maximizes symmetry of the lip and is designed to reorient the orbicularis oris muscles from each lateral lip segment across the central prolabial segment. Intact lip musculature improves lip aesthetics and decreases tension across the two vertical lip incisions (Fig. 1-35).¹⁰³

Palatoplasty

The goals of cleft palatoplasty are normal speech development and prevention of nasal regurgitation by closure of the congenital oral nasal fistula. Successful repair requires adherence to several important surgical principles, which include adequate flap mobilization to minimize wound tension, atraumatic technique to minimize injury to flap vessels, two-layered closure of the oral and



FIGURE 1-35 (A) Photograph of a patient (age unspecified) with a bilateral cleft lip and palate. (B) Postoperative photograph of the patient at 3 years of age after bilateral cleft lip repair.

TABLE 1-17 PRINCIPLES OF PALATOPLASTY

Minimization of wound tension
Atraumatic technique
Two-layer closure of oral and nasal layers
Re-creation of soft palate muscular sling

nasal mucosa to prevent postoperative fistula formation, and re-creation of the soft palate muscular sling to maximize velopharyngeal function and speech (Table 1-17).¹⁰⁴

The specific technique used to repair palatal clefts is based on the surgeon's experience and the cleft type. In all cases, an atraumatic "no-touch" technique should be used to minimize injury to the palatal wound edges and to maximize blood supply to the periphery of the palatal flaps. Monopolar cautery should be avoided. It is important to re-create the velopharyngeal muscular sling to minimize the chance of postoperative velopharyngeal dysfunction. If the above-mentioned principles are followed, postoperative fistulas are rare and the incidence of velopharyngeal dysfunction can be minimized.

TIMING OF CLEFT PALATE REPAIR

The timing of repair of cleft deformities was outlined in Table 1-12. In all patients with cleft palate, tympanostomy tube placement is performed to aerate the middle ear and to minimize the chance of chronic ear disease. In patients with both cleft lip and palate, cleft lip repair is performed at ~3 months of age. At the time of lip repair, tympanostomy tubes are also placed. Cleft palate repair occurs between 9 and 18 months of age, prior to the initial

development of speech. Long-acting tympanostomy tubes are placed at the time of palatoplasty. After cleft palate repair, yearly speech evaluation, beginning at 2 years of age is essential to identify VPD. If VPD is identified, evaluation including nasopharyngoscopy and videofluoroscopy is performed to quantify the amount of VPD.

Other interventions for the cleft patients (including orthodontic therapy, alveolar bone grafting, cleft nasal reconstruction, and orthognathic surgery) are related to the degree of the original deformity and the growth of the face. It can be noted that in cleft patients who do not undergo palatoplasty at a young age, midfacial growth is normal.¹⁰⁵ Ross¹⁰⁶ has noted that midfacial growth disturbance is most related to the type of cleft palate repair and the timing of palatoplasty. The decision to perform palatoplasty at approximately 1 year of age is made to improve speech and with the knowledge that facial growth may be altered.

Von Langenbeck Palatoplasty

In the early 19th century, elevation of bipediced mucoperiosteal flaps to close clefts of the hard palate was first reported independently by Dieffenbach,¹⁰⁷ Warren,^{108,109} and von Langenbeck.¹¹⁰ This method involves incisions along the cleft margin (medial) and adjacent to the alveolar ridge (lateral). Undermining the bipediced flaps in the subperiosteal plane allows flap release and advancement. The bipediced flaps can be approximated in a "draw-bridge" fashion to achieve closure of the hard-palate cleft.

The bipediced flap palatoplasty (often called the von Langenbeck repair) employs several important principles of palatoplasty (Fig. 1-36). The most important idea is

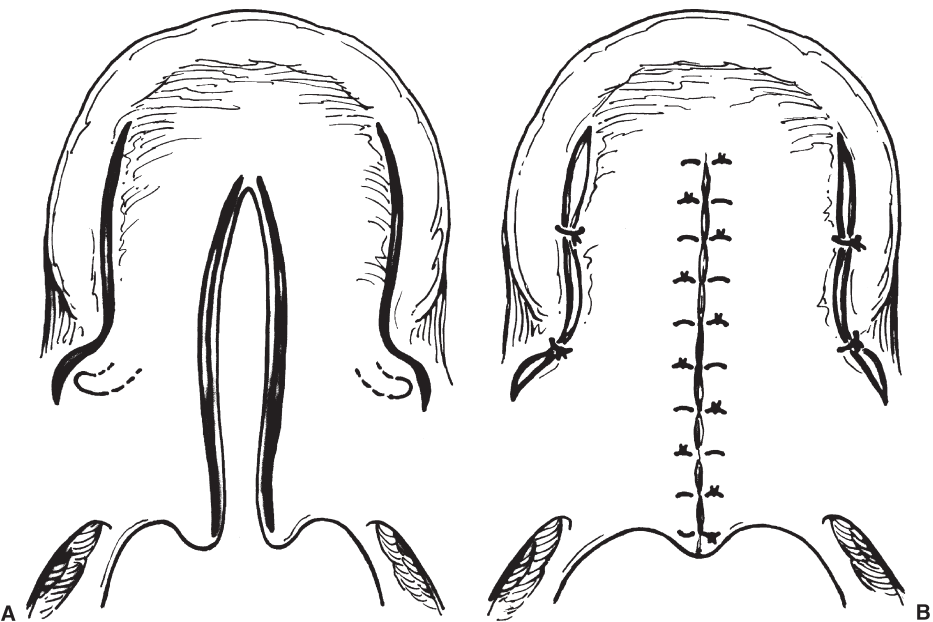


FIGURE 1-36 (A) Schematic diagram showing the incisions of the bipediced von Langenbeck cleft palate repair. (B) Schematic diagram showing closure after the von Langenbeck palatoplasty procedure. (From Papel ID. Facial Plastic and Reconstructive Surgery, 2nd ed. New York: Thieme, 2002, with permission.)

the use of two-layered closure (oral and nasal layers). A two-layered closure decreases the incidence of postsurgical fistula when compared with the fistula rate of closure of only the oral layer. In a two-layered closure, if there is slight wound breakdown of either the oral or the nasal layer, a fistula usually does not result, as the other intact layer often prevents fistula formation. The other important principle in the bipedicle flap technique is adequate flap mobilization to minimize tension across the wound edges.

The major disadvantage of the von Langenbeck palatoplasty is in not allowing visualization of the vascular pedicle of the palatal flaps. The greater palatine vascular pedicle is located ~1 cm medial to the upper second molar tooth. Identification of this pedicle allows greater flap mobilization and can decrease wound tension in wide palatal clefts. For this reason, most surgeons connect the medial and lateral cleft incisions anteriorly, thereby converting the bipedicle flaps to posteriorly based unipedicle flaps. These three-flap (incomplete clefts) and two-flap (complete clefts) repairs allow increased visualization of the vascular pedicle, increased flap mobilization, and decreased wound tension.

Three-Flap Palatoplasty

The three-flap palatoplasty is used to repair clefts of the secondary palate (the entire soft palate and the hard palate posterior to the incisive foramen). The medial cleft incisions are the same as the incisions used in the bipedicle flap technique (Fig. 1-37A). The lateral incisions are made adjacent to the tooth crowns and carried around the maxillary tuberosity. The medial cleft margin and

lateral incisions are joined anteriorly by oblique incisions that connect at the level of the canine teeth laterally. This converts the bipedicle flaps to posteriorly based unipedicle mucoperiosteal flaps.

The posteriorly based unipedicle flaps are elevated in a submucoperiosteal plane and contain the greater palatine vessels. After the nasal mucosa is elevated, complete closure of the nasal layer is accomplished prior to muscle closure and to oral mucosal closure. Dissection and release of the malaligned soft palatal musculature is performed and the muscle is then closed in a single layer. This allows repositioning of the velopharyngeal muscular sling from an oblique to a more physiologic transverse orientation.

After closure of the nasal layer and the posterior muscular layer, the oral layer is closed in a single layer approximating the medial cleft margin incisions (Fig. 1-37B). At least one “tacking” suture is used to coapt the oral and nasal layers and to prevent dead-space and hematoma formation.

Two-Flap Palatoplasty

The two-flap palatoplasty technique is used to repair complete palatal clefts (of the entire primary and secondary palate). The exact technique for unilateral versus bilateral complete clefts is slightly different. In the complete unilateral cleft palate, the medial cleft margin incisions are carried anteriorly almost to the alveolar cleft (Fig. 1-38A). These medial incisions are joined to two curved lateral incisions, creating two posteriorly based palatal flaps (Fig. 1-38B).

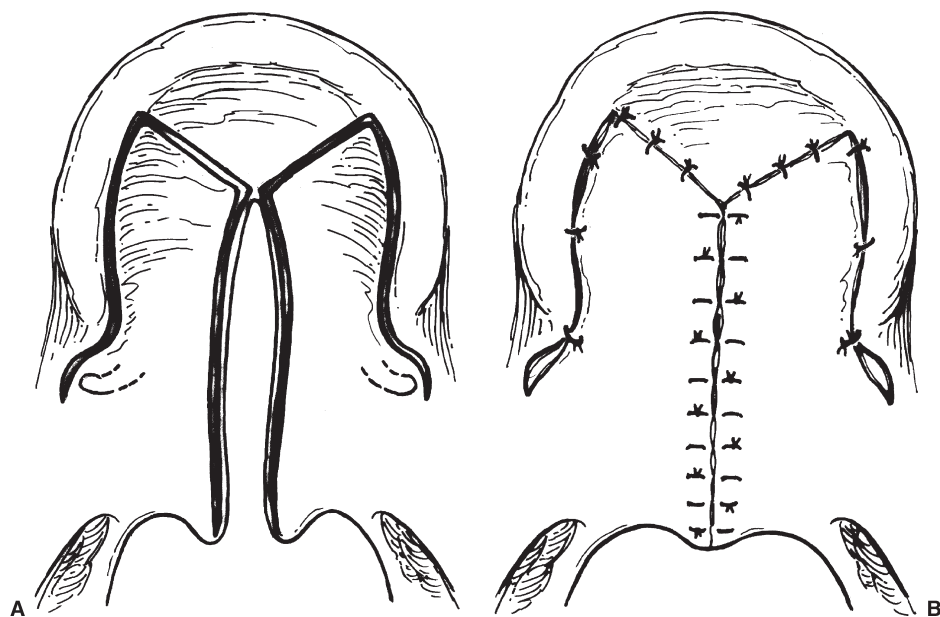


FIGURE 1-37 (A) Schematic diagram of the incisions for the three-flap palatoplasty. (B) Schematic diagram after closure of the nasal and oral layer of the three-flap palatoplasty for repair of the complete secondary cleft palate deformity. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

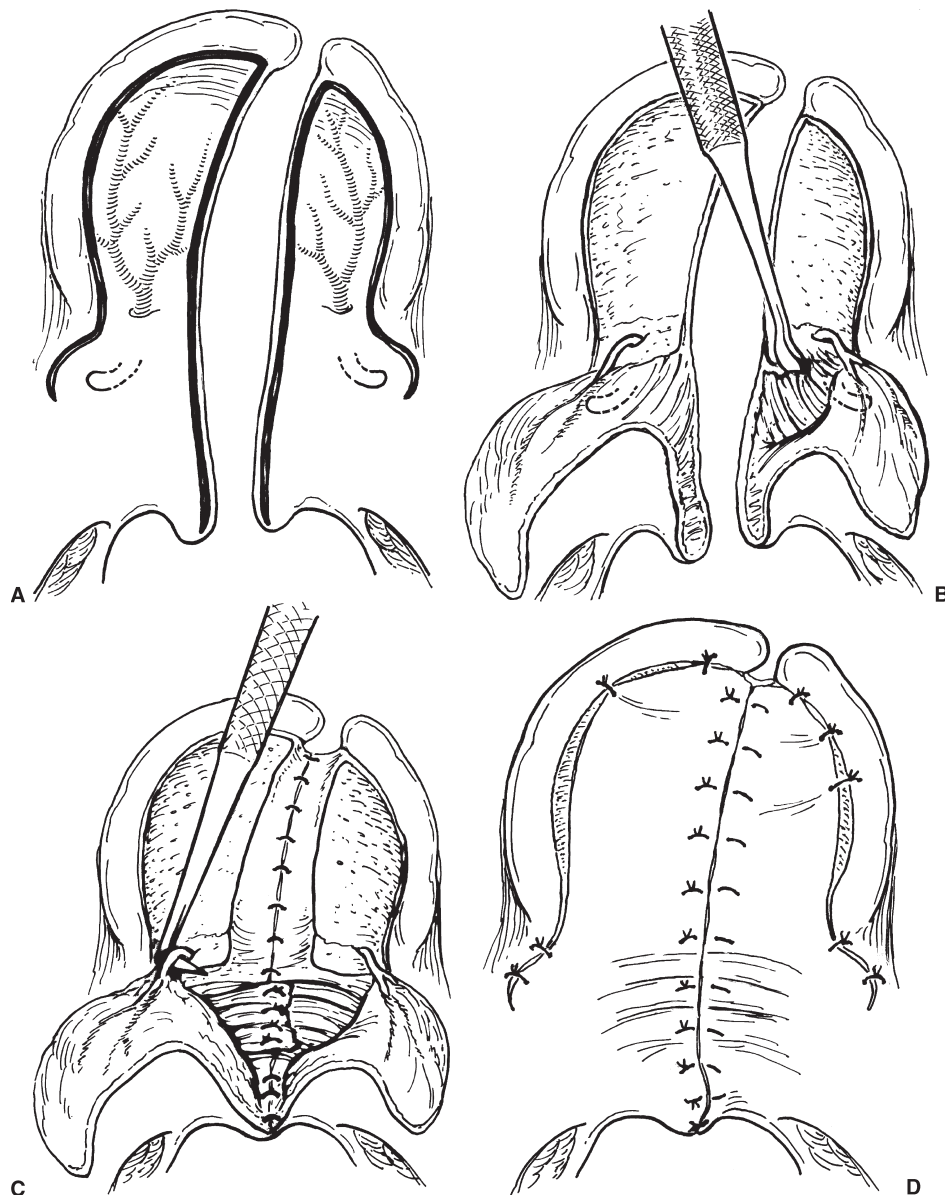


FIGURE 1-38 (A) Schematic diagram of the incisions for a two-flap palatoplasty for repair of complete unilateral cleft palate deformity. (B) Elevation of the flaps and subperiosteal plane dissecting out the greater palatine arteries bilaterally. (C) Dissection posterior to the greater palatine arteries in the space of Ernst. Note that the nasal mucosa and soft palate musculature have been closed and the oral flaps await closure. (D) Repair of the oral mucosa in a complete unilateral cleft palate deformity. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

The principles of elevation are the same as in other cleft palate techniques. Subperiosteal flap elevation with an atraumatic technique is performed to expose and isolate the neurovascular pedicles. After flap elevation, the palate is again repaired in layers, beginning with the nasal layer (Fig. 1-38C). The soft-palate musculature is again closed with interrupted sutures, decreasing the tension across the palatal wound. Closure of the oral palatal mucosa followed by a coapting suture is then performed (Fig. 1-38D). In complete clefts, the entire cleft with exception of the anterior alveolar cleft is thus closed.

Furlow Palatoplasty

The double-reversing Z-plasty, or Furlow palatoplasty, was first described by Leonard Furlow^{111,112} in 1978. This technique is usually used to repair a submucous cleft or a cleft of the soft palate only. The technique involves the creation and closure of two opposing Z-plasties of the oral and nasal mucosa. The repair is designed to lengthen the palate and re-create the muscular sling of the soft palate.

The central limbs of the double-reversing Z-plasty technique are made at the margin of the soft palate cleft. If the technique is performed on a submucous cleft of

the soft palate, without through-and-through clefting, a full-thickness incision is made through the palate in the midline to create a soft palate cleft. On one side, an incision is made extending from the cleft margin obliquely toward the hamulus laterally (Fig. 1–39A). Dissection is carried on this side deep to the soft palatal musculature. This posteriorly based oral mucosal flap contains both oral mucosa and soft-palate muscle (Fig. 1–39B). On the opposite side, an incision is made in the oral mucosa from the uvula to the ipsilateral hamulus. This triangular oral mucosal flap does not contain soft palate musculature.

On the nasal side, mirror-image incisions (to the oral mucosal incisions) are then made to create two triangular-shaped nasal flaps (Fig. 1–39C). The anatomy of the soft palate musculature is important in dissection, elevation, and transposition of the oral and nasal flaps (Fig. 1–39D). In that the levator veli palatini muscles are located immediately adjacent to the nasal (not the oral) mucosa, elevation of these muscles from the nasal mucosa is often difficult (Fig. 1–40). It is important that the muscular sling of the soft palate be reoriented to a horizontal direction during closure of the Z-plasty flaps. For this

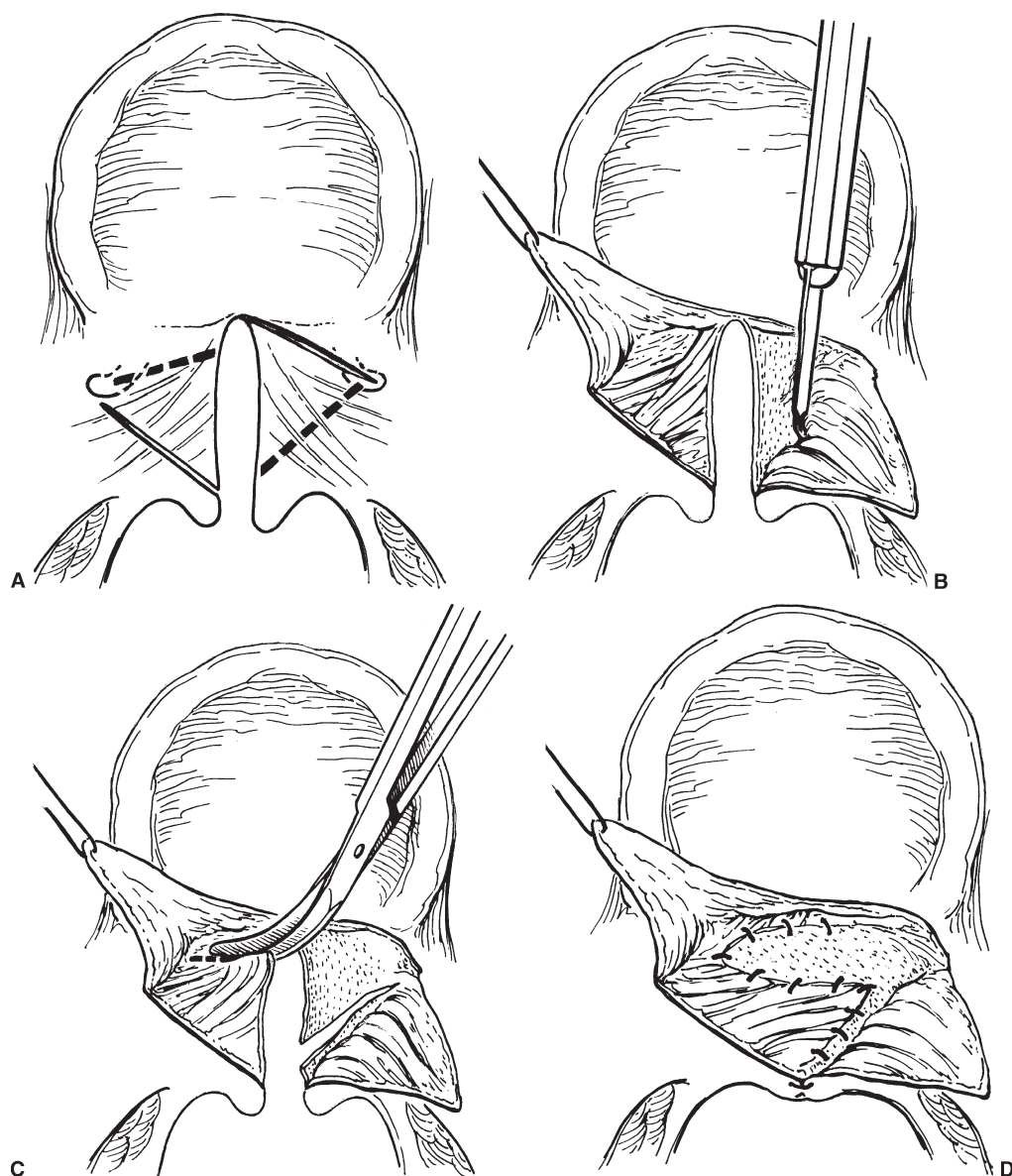


FIGURE 1–39 (A) Schematic diagram of the double-reversing Z-plasty (Furlow palatoplasty). Note that the dotted lines indicate the nasal incisions and the straight lines indicate the oral incisions. (B) Elevation of the oral flaps bilaterally. Note that the patient's left flap is elevated below the musculature, so that the oral flap contains both oral mucosal and palatal musculature. The right flap contains only oral mucosal. (C) Incision of the nasal flaps with curved scissors on the nasal side. (D) Closure of the nasal mucosal and palatal musculature. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

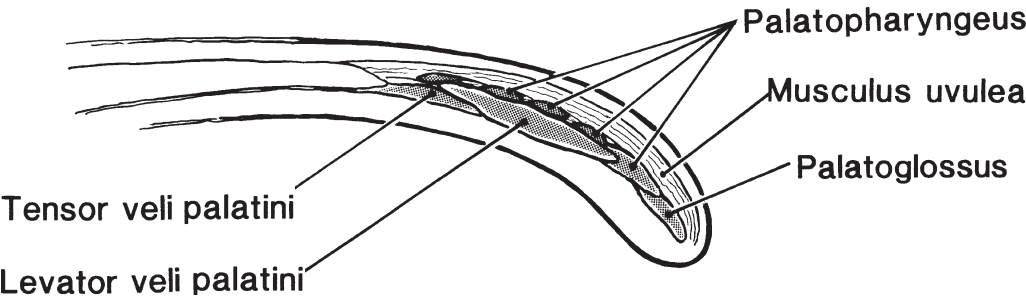


FIGURE I-40 Sagittal view of the soft palate showing that the palatal musculature is closer to the nasal mucosal than it is to the oral mucosal. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

reason, the soft palate musculature must be based posteriorly within the flaps. Right-handed surgeons can more easily perform the difficult dissection of the soft palate musculature from the nasal mucosa on the patient's left or contralateral side; left-handed surgeons should design the incisions in the mirror image.

After dissection of both oral and nasal flaps, transposition of all four flaps is accomplished. The nasal flaps are first transposed and reapproximated. The soft palate muscular sling is then reoriented and closed with 4-0 braided absorbable suture. The oral flaps are then reapproximated (Fig. 1-41). Postoperative fistula is usually prevented in that the oral and nasal suture lines do not overlie one another. This technique both lengthens the palate and re-creates the velopharyngeal muscular sling.

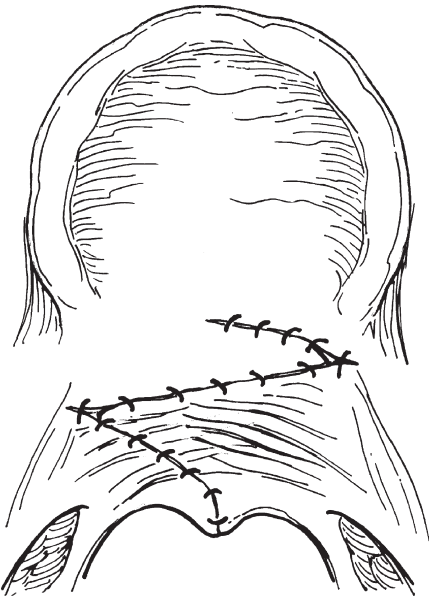


FIGURE I-41 Double reversing Z-plasty, palatoplasty after closure of the oral mucosal. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

Preferred Techniques of Palatoplasty

The preferred surgical techniques for repair of cleft palate are summarized in Table 1-18.¹¹³ They include two-flap palatoplasty for complete unilateral and bilateral clefts, three-flap palatoplasty for incomplete and complete clefts, and double-reversing Z-plasty (Furlow's technique) for submucous clefts and cleft of the soft palate only.

Uncommon Cranial Facial Clefts

Clefting of the upper lip, maxilla, and palate is the most common set of congenital anomalies of the head and neck. Clefts of the upper lip and palate tend to occur in predictable and recognizable patterns. However, a variety of other congenital clefts of the soft tissue and bones of the face exist. Again, these clefts occur as a result of incomplete or interrupted mechanisms of embryogenesis.

Many classification systems for oral facial clefting have been described. Some of these are anatomic, some are descriptive, and others represent named syndromes or portions of these syndromes that involve facial clefting. Facial clefts can occur in a median or vertical orientation, in a lateral or horizontal orientation, or can occur obliquely. In many instances, the embryologic insult is not easily described, and the ideology, therefore, is not known. However, anatomic descriptions of these clefts are usually helpful.

Lateral Facial Clefts

Lateral facial clefts originate from the lateral oral commissure. Lateral clefting (macrostomia) may be an isolated phenomenon, or associated with other anomalies

TABLE I-18 PREFERRED PALATOPLASTY TECHNIQUES

Cleft Type	Technique
Complete unilateral	Two-flap
Complete bilateral	Two-flap (with vomerian flaps)
Incomplete and complete secondary	Three-flap
Soft palate	Double-reversing Z-plasty
Submucous	Double-reversing Z-plasty



FIGURE 1-42 Frontal (A) and lateral (B) views of a 6-month-old Asian boy with bilateral preauricular skin tags containing cartilage, hemifacial microsomia, and severe left-sided macrostomia.

and be syndromic (Fig. 1-42). The most common syndromes include mandibulofacial dysostosis, OAV spectrum, Nager acrofacial dysostosis, or other syndromes. The manifestation of these clefts can be extremely mild, with slight widening of the ipsilateral oral commissure, or can result in frank macrostomia with dehiscence of the orbicularis oris muscles. Lateral facial cleft may be associated with other facial anomalies, such as skin tags along the mandible or in the preauricular region, other auricular or ocular anomalies, or other abnormalities of the branchial arches. A common association with macrostomia is the OAV spectrum. This may involve hypoplasia of the hemimandible and the hemiface, epibulbar dermoids, colobomas of the upper eyelid, and abnormalities of the ear, including microtia.

The estimated frequency of isolated lateral facial clefts is between 1 in 100 and 1 in 350 cases of cleft lip and/or palate. Statistically, the incidence of isolated lateral clefts is then 1 in 50,000 to 1 in 175,000 live births.^{81,82} There appears to be no genetic basis for lateral facial clefting. The lateral facial cleft may be unilateral or bilateral and may be partial or complete. When complete, the cleft may extend from the angle of the mouth to the ear. Lateral facial clefting is more common in males than in females and is more frequent on the left side. Anomalies associated with lateral facial clefting include absence of digits, micrognathia,¹¹⁴ nasal dermoid, bifid uvula, and redundant teeth.

Oblique Facial Clefts

Oblique facial clefts, also called meloschisis, are very rare, reported in only 1 of 1300 cases of facial clefting.⁸² Wilson et al¹¹⁵ estimated that oblique facial clefts represent only 0.25% of all clefts. Oblique clefts are bilateral in ~20% of cases and are more common on the right side when they are unilateral.¹¹⁶

Oblique facial clefts vary in their extent. The extreme and severe types are usually incompatible with life. Oblique facial clefts may extend into the upper lip and nose and involve the unilateral eye, brow, or temple.¹¹⁷

They can be associated with the amniotic rupture sequence. Associated anomalies with oblique facial clefts include hernias, genital urinary abnormalities, talipes, spinal and costal defects, and hydrocephalus.¹¹⁸

Tessier Classification for Facial Clefting

Tessier¹¹⁹ proposed a classification system in 1976 that described clefts based on their anatomic classification. His system related all facial clefts to the sagittal midline. The classification system does not describe the ideology or pathogenesis of clefting, but numbers clefts according to their radial orientation with the sagittal midline. Both skeletal and soft tissues are involved, but their manifestations are not equally common. From the sagittal midline to the infra-orbital foramen, abnormalities of soft tissue are more common. From the infraorbital foramen laterally to the temporal bone, bony abnormalities are more prevalent than are those of soft tissue. The exception to bony abnormalities being more common in the lateral face is the ear. Clefts through the bony orbit use the lower eyelid as the horizontal equator. Radially oriented numbered lines may be either northbound (cranial) or southbound (facial). Cranial or superiorly oriented numbered lines have facial or inferiorly oriented numbered counterparts, but these numbers are different, thus precluding the notion that the cranial and facial clefts have the same pathogenesis (Fig. 1-43).

Frequently, soft tissue defects may predict that underlying bony clefts are present. An example of this is notching of the upper or lower eyelids alar rim. These soft tissue clefts are frequently associated with underlying orbital (Fig. 1-44) or bony nasal or maxillary associated abnormalities. The overlying soft tissue abnormalities are referred to as Tessier signs.¹²⁰ Many of these clefts cannot be explained embryologically and suggest the possibility not only of malformation but also of disruptive factors.

Median Cleft Lip

Median cleft lip describes a single midline lack of migration of soft tissue. Median clefting of the upper lip

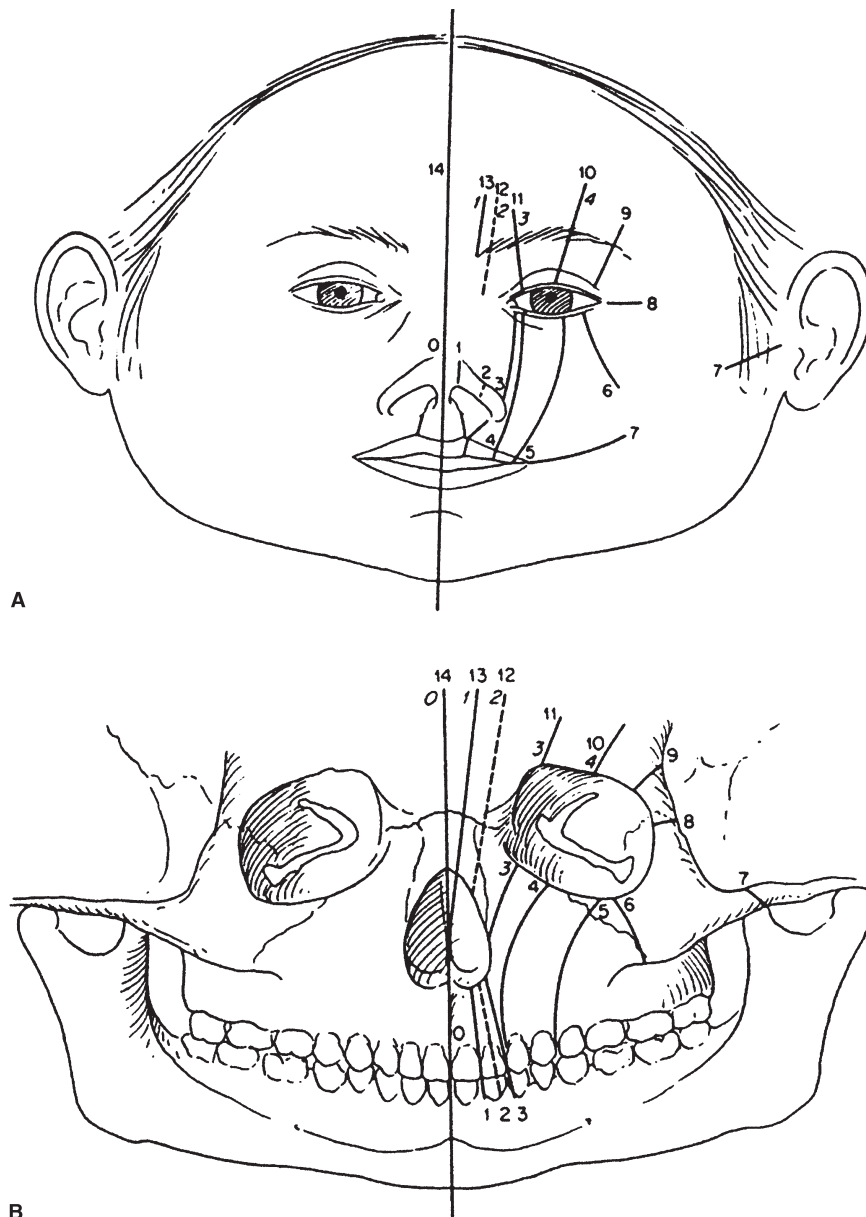


FIGURE 1-43 (A) The Tessier cranial facial clefting classification system identifies the soft tissue clefts of the mid and upper face. (B) Bony clefts of the Tessier classification system. The dotted lines represent nonspecific or uncertain localization of clefting. The northbound cranial line has a different number than its counterpart southbound facial line. (From Tessier P. Anatomic classification of facial, cranial-facial and lateral-facial clefts. *J Maxillofac Surg* 1976;69, with permission.)

represents a failure of migration of the median nasal prominences to approximate in the midline.^{121,122} This cleft is extremely rare, with an incidence of only 0.2% of all facial clefts. Clefting of the central aspect of the upper lip may occur in isolation or be associated with some form of holoprosencephaly.

Median clefts of the upper lip may involve the lip only, the columella and central aspect of the nose, and the nasal septum. It is often associated with widening or bifidity of the nasal tip (Fig. 1-45). When associated with holoprosencephaly, there may be a genesis of the nasal dorsum, absence of the olfactory tracts and bulbs, hyperptelorism,

and abnormal formation of intracranial structures.^{122,123} Median clefts of the upper lip may be associated with several syndromes including OFD syndrome, Ellis-van Creveld syndrome, and Majewski syndrome. Severe forms are often associated with mental retardation.

CONGENITAL MALFORMATION OF THE AURICLE

Congenital malformation of the auricle represents a spectrum of anomalies, ranging from a small external ear



FIGURE I-44 A 3-month-old with oblique cleft of the right side of the face involving the lateral alar base of the nose, the lacrimal system, and the orbit, including congenital and anophthalmia.

with minimal structural abnormality to an ear with major external, middle, and inner ear deformities. The creation of an external ear in a child with a congenital auricular deformity is both a challenging and a rewarding experience. Many different methods and materials have been used to repair the malformed ear. These have included the fabrication and placement of external prostheses,



FIGURE I-45 A 4-year-old boy with broad nasal dorsum and bifidity of the nasal tip. This patient also had a bifid nasal septum.

the placement of auricular frameworks composed of homograft cartilage¹²⁴ and various alloplasts,^{125,126} and staged reconstruction utilizing autologous cartilage grafts. The variation in approach and technique is indicative of the difficulty in achieving consistent and reproducible esthetic results. Reconstruction of the malformed ear requires a thorough understanding of the normal anatomy of the auricle. This section discusses the embryology, anatomy, philosophy and timing of reconstruction, and techniques of reconstruction of the microtic auricle.

EMBRYOLOGY OF THE EAR

The developing human ear can first be seen in stage 9 of development at ~20 days' gestation with the presence of the otic disc.¹²⁷ The otic disc appears as a thickening of surface ectoderm opposite the rhombencephalic fold. At ~22 days gestation, the otic disc invaginates and is referred to as the otic pit. The communication between the external surface and otic pit eventually goes away and the blind pit or otic vesicle gives rise to the structures of the inner ear.¹²⁸

The external ear develops from the pharyngeal apparatus and is first noticed on the lateral aspect of the 39-day-old embryo.¹²⁹ Along the margins of the first branchial groove arise six hillocks or tuberosities (Fig. 1-46). These tuberosities are known as the hillocks of His. Three hillocks develop from the caudal border of the first arch, and three develop from the cephalic border of the second arch. The hillocks increase in size secondary to mesenchymal proliferation and reach their maximal size at ~41 days' gestation. The auricle develops in the upper portion of the future neck region, and as the mandible grows, the auricles move to the side of the head. As the fetus grows, the auricle ascends to the level of the eyes. The first auricular hillock gives rise to the tragus, and the second and third hillocks form the crus helix. The fourth and fifth hillocks become the crura anthelices and the helix, and the sixth hillock develops into the antitragus.¹²⁷

Abnormalities in development of the ear may occur with any of the hillocks. The extent of the eventual auricular deformity is based on the number of hillocks affected and the degree of malformation and insult to the hillock. For this reason, a large number of auricular deformities exist. For instance, an abnormality of hillock three can exist where the first branchial groove begins closing at the upper cephalic end of the embryo. Abnormal closure in this region will lead to malformed superior-anterior helices. The extent of this deformity may range from mild with an absent anterior helix, to a classical "lop" ear with lack of the superior crus of the antihelix and the shortened scapha. Abnormal fusion of hillocks three and four may lead to an irregular border of the superior aspect of the helix with a cleft, much like the malformation associated with clefting of the lip.

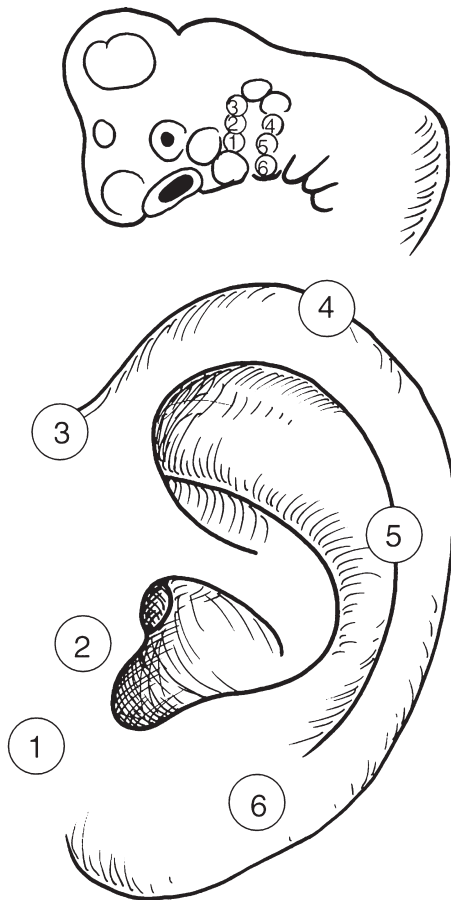


FIGURE I-46 The hillocks of His in the embryo. These arise from the first and second branchial arches. Their corresponding locations in the fully developed auricle are shown.

Malformations of hillock four alone create abnormally shaped helical domes and adjacent scapha. Abnormal fusion of hillocks four and five lead to a prominent Darwin's tubercle. A cleft can arise in hillocks four and five that leads to a more severe malformation than a Darwin's tubercle. In this case, there is a discontinuity of the helical rim with severe angulation of the posterior aspect of the rim. Abnormalities of fusion of hillocks five and six result in abnormal fusion in the region of the inferior helix, antitragus, and lobule.

Lack of development of hillocks two, three, four, and five leads to the classic congenital auricular deformity known as microtia (Fig. 1-47). Abnormalities and overgrowth of hillock two may lead to preauricular tags and polyotia (cartilage containing supernumerary appendages). This reduplication or abnormality of the auricle and preauricular skin may be seen in isolation, in association with congenital syndromes such as the OAV spectrum, or may be present in varying forms of microtia.

The external ear develops in the child at a rate different from that of most other features of the face. At birth, the ear is similar in size in both sexes, but as children grow, there is a different growth rate of the ear for each



FIGURE I-47 Photograph of a classic right microtia.

sex. Farkas¹³⁰ states that the external ear reaches 85% of its adult size by age 6, 90% by age 9, and 95% by age 14. Timing of surgery on congenital auricular deformities therefore usually occurs between the ages of 5 and 10. Considerations for timing include overall development of the child, psychosocial concerns and possible peer ridicule, and development of tissues to possibly reconstruct the ear, such as the rib cage.

ANATOMY OF THE EAR

A thorough understanding of the normal anatomy and architecture of the external ear is crucial to reposition or sculpt an existing auricular framework, or to construct a new one. The external ear is a cartilaginous structure with the exception of the lobule, which contains only skin and fibrofatty tissue. The auricular framework is composed of flexible elastic cartilage, which is covered by skin and a very thin layer of subcutaneous tissue. The soft tissue envelope is tightly adherent anteriorly and more loosely attached posteriorly. The cartilage gives rise to various concavities and convexities, which are known by surface landmarks that give the ear a unique shape and orientation.¹³¹

The relationship of the external ear to various other facial features is an important physical characteristic of the side of the head. The normal auricle protrudes in absolute distance from ~18 to 25 mm. The angle between the posterior skin of the ear and the skin of the mastoid process is ~30 degrees or less. The vertical orientation of the ear is slightly less inclined than the average dorsum of the nose. In boys, the mean angle of inclination is 21 degrees from vertical, and in girls the mean inclination

from vertical is 20 degrees.^{132,133} The position of the ear in an anterior-to-posterior direction should be ~7 cm from the lateral canthus. The lateral canthus to helical crus distance should be approximately equal to the vertical length of an auricle. This measurement is important in microtia repair as the placement and orientation of the newly constructed auricle has a lot to do with creating a natural appearance to the auricle.

The auricular cartilage is attached to the skull by three ligaments. The anterior ligament attaches the helix and tragus to the zygomatic process of the temporal bone. The front portion of the cartilaginous external auditory canal is free of cartilage, but is bridged by a ligament passing from the tragus to the helix.

The external ear has several muscles (supplied by the seventh cranial nerve), which enable the ear to have fine movements either in conjunction with or independent of movements of the scalp. There is no important function of these muscles, although some individuals have a large amount of control of the periauricular muscles and are able to move and wiggle their ears accordingly.

TIMING OF MICROTIA REPAIR

The decision to perform microtia repair is a complex one. It requires consideration of developmental, medical, and psychological factors. Repair of this congenital deformity is best performed prior to the age when peer ridicule starts, but after sufficient growth of the thorax has occurred. Adequate rib growth is necessary to provide enough cartilage for the creation of an auricular framework. Additionally, the child must be generally aware of the problem and understand the surgical process to cooperate postoperatively. Deciding the exact timing of microtia repair entails the consideration of auricular growth, the size of the rib cage, the psychological needs of the patient, and the parents' desires.

Rib cartilages are typically large enough to provide an adequate auricular framework by 6 years of age. At this time, growth of the opposite external ear is ~85% complete. If the normal ear is small and the child is large, the first stage of the repair may be started by age 5. But if the normal ear is large and the child small, auricular reconstruction is best delayed until after the age of 6. In any case, surgical construction of the microtic ear should not be started unless there is a strong communication between the family and surgeon, with attention to the psychological aspects by the surgeon, and an understanding of the staged nature of the surgery by the parents.

It is clear that the best results from microtia repair are usually from the first attempt, at a time when the native skin is previously unviolated. Thin skin drapes easily over the cartilaginous framework, allowing maximal visualization of auricular detail. If the skin of the ear has been violated by previous trauma or surgery, auricular detail is

obscured, despite the creation of an anatomically correct cartilaginous framework. For these reasons, the family and child should be prepared to follow postoperative instructions carefully to avoid postoperative trauma.

SURGICAL TREATMENT OF CONGENITAL MALFORMATION OF THE AURICLE

Three to four stages are typically required for successful auricular reconstruction (Table 1–19): stage 1, harvest, fabrication, and placement of the auricular framework; stage 2, lobule transposition; stage 3, placement of a skin graft with creation of a postauricular sulcus; and stage 4, tragal construction and conchal excavation.^{134–138} A minimum of 3 months between stages is required to allow swelling to subside and to increase vascularity to the overlying skin.

PREOPERATIVE CONSIDERATIONS

An individual's attractiveness is never defined by the beauty of their ears. However, a deformed or malpositioned auricle can detract from one's appearance. It is very important to keep these factors in mind when outlining surgical goals to the patient and family. Because most observers do not view both ears simultaneously, minor asymmetries of detail between the ears are often overlooked. However, gross differences in size or position of the two ears are easily noticed. It is therefore crucial to measure the size of the ear to be constructed carefully and to determine accurately the position and orientation of the auricular framework.

A detailed pattern of the opposite normal ear is traced on radiographic film. The pattern is then reversed to be used as an intraoperative template when harvesting and carving the auricular framework (Fig. 1–48). The template is usually cut ~3 mm smaller than the outer dimensions of the normal ear to allow for the thickness of the skin overlying the ear. In cases of bilateral microtia, auricular size and template formation must be estimated from age-matched children. It is important in cases of bilateral microtia not to create too large a template, so as not to create too large an ear.

The position and orientation of the reconstructed ear is very important and should be determined preoperatively. This is accomplished in the surgeon's office by

TABLE 1–19 STAGES OF AURICULAR RECONSTRUCTION

Stage 1	Harvest, fabrication, and placement of auricular framework
Stage 2	Lobule transportation
Stage 3	Lateralization of the auricle (with split-thickness skin graft)
Stage 4	Tragal construction and conchal excavation

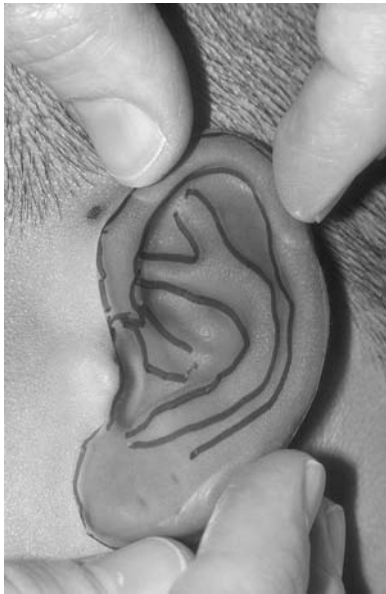


FIGURE 1-48 Establishment of the position and orientation of the reconstructed ear by tracing a pattern of the normal ear on radiographic film. Several of these templates are made to be used intraoperatively to determine the position and orientation of the ear and to determine the size of the costal cartilage to be harvested. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

taping a reversed film pattern to the patient's head and tracing the outline of this pattern on the patient's head.

The ear should be positioned approximately one full ear's length from the lateral canthus. A horizontal line (drawn parallel to the Frankfort horizontal) at the level of the lateral canthus should intersect the superior helical root. The anterior-posterior position of the newly constructed ear must often be modified in the patient with significant facial asymmetry (e.g., significant hemifacial microsomia). If the microtic ear is associated with hemifacial microsomia, placing the framework one ear's length from the lateral canthus will position the ear too far posteriorly. If the hairline only is used to position the new ear framework, the ear will be placed too anteriorly. In these cases, a compromise between these two positions should be used to determine the correct position for the auricular framework.

The orientation of the newly created ear is also very important. It is quite common for inexperienced surgeons to place the ear in too upright a position. The orientation of a normal ear is ~15 degrees from vertical (Fig. 1-49). This can be approximated by halving the angle from vertical (0 degrees) and that of the nasal dorsum (30 degrees from upright). Proper position and orientation is crucial and should be determined and marked preoperatively.

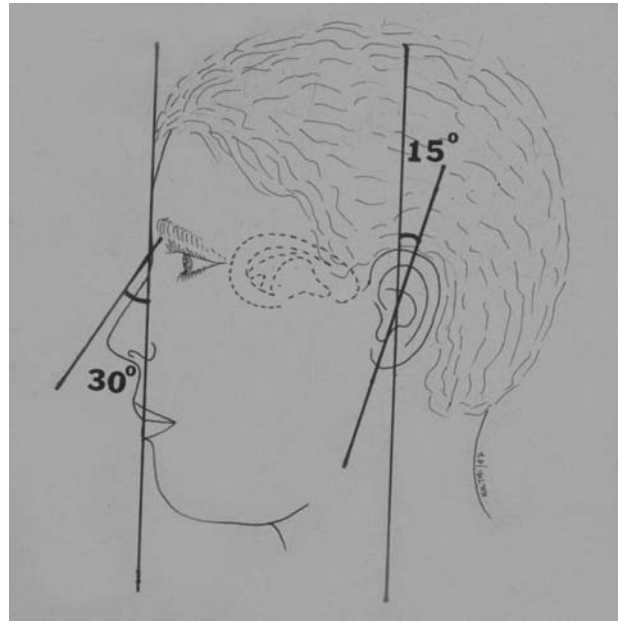


FIGURE 1-49 Schematic diagram of the position and orientation of a normal ear, showing it approximately one full ear's length from the lateral canthus of the eye and 15 degrees from a vertical orientation. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

Stage 1: Harvest, Sculpting, and Placement of the Auricular Framework

Preparation of the Skin Pocket

Prior to prepping and draping the patient, the position, size, and orientation of the auricle is checked and outlined over the microtic ear. It is important not to remove the outlined marking when prepping the patient, as the precise position and orientation of the auricular framework is a key factor in obtaining a good result. A sterile, clear plastic drape is used over the face to allow visualization of both sides of the head simultaneously.

Removal of the cartilaginous portion of the microtic remnant and dissection of the pocket is usually performed after harvest of the rib cartilage and sculpting of the auricular framework. This waiting period is used for vasoconstriction, as rib harvest and sculpting of the framework usually requires more than 2 hours. Prior to preparing the auricular pocket, a small amount of Xylocaine 1% with epinephrine 1:100,000 is used for vasoconstriction. An incision is made just anterior to the microtic remnant. This incision should be just large enough to allow placement of the carved auricular framework and removal of the existing cartilage remnant. The entire auricular cartilage is then removed (Fig. 1-50). However, the soft tissue of the microtic remnant is preserved for later reconstruction of the auricular lobule. Complete cartilage removal enhances



FIGURE 1-50 Intraoperative view of a microtic ear using an anterior incision to remove the auricular cartilage remnant completely. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

coaptation of the skin to the newly created auricular framework. Careful dissection of the pocket in the subdermal plane is then performed. The area dissected should extend slightly beyond the premarked outline to create sufficient skin laxity for skin redraping over the auricular framework (Fig. 1-51). The skin should then be thinned to allow maximal redraping. In ears that have had prior surgery, increased skin thickness may prevent fine auricular definition.

Harvesting the Rib Cartilage

The configuration of the contralateral rib cage forms the most favorable material for auricular grafting (Fig. 1-52). The three-dimensional nature of the naturally shaped ear requires a multilevel framework. The floating, or mobile,

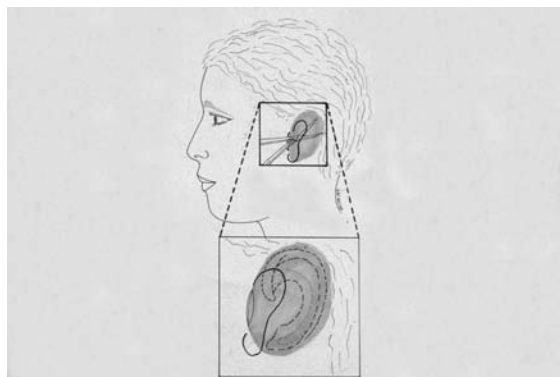


FIGURE 1-51 Schematic diagram of the premarked dissection pocket for the auricular framework. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

rib is well suited to form the helix and helical root, whereas the synchondrosis of ribs 6 and 7 form the framework body (superior and inferior crura, antihelix, and conchal bowl).

The floating rib is palpated, and an oblique incision is marked just superior to the costal margin. Vasoconstriction is obtained with infiltration of epinephrine 1:100,000. An oblique incision (measuring three-fourths the length of the costal margin) is made parallel and just inferior to the costal margin. The upper fibers of the rectus abdominus muscles are divided to expose the thorax, and a large self-retaining retractor is used for exposure. A precut separate sterilized film template (of the normal ear) is placed directly in the chest wound to determine the size and orientation of the cartilage to be harvested. Meticulous sub-perichondrial dissection is performed to separate the rib cartilages from the parietal pleura. Special care must be taken in the lateral intercostal spaces, where dense adherence of the pleura to the ribs may occur. If a small hole is made in the pleura, closure of the hole is performed with a purse string suture (4-0 braided synthetic suture) around a soft catheter. After the purse-string suture is placed, the catheter is removed on forced mechanical

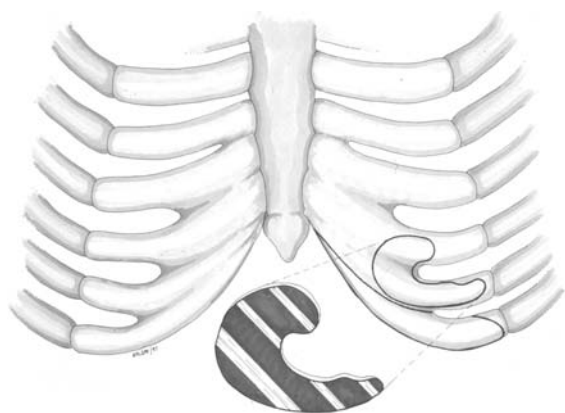


FIGURE 1-52 Schematic diagram of the rib cage showing the area of synchondrosis for harvesting of the auricular framework body. Note the contralateral rib cage forms the most favorable configuration for the auricular framework. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1-53 Typical appearance of the floating rib and synchondrotic portion of the sixth and seventh ribs prior to sculpting into an auricular framework. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

(bagged) ventilation during expiration. Watertight closure may be checked by filling the wound with saline and looking for bubbles during deep inspiration. If these methods are used, postoperative pneumothorax is rare.

After subperiosteal dissection of the rib cartilages is completed, the floating rib (or ribs) and the synchondrotic portion of the graft are removed separately (Fig. 1-53). Care must be taken to remove the entire floating rib, as this portion is often deficient in length.

The chest wound is closed in layers with a 3-0 braided synthetic absorbable suture used for muscle and a 4-0 absorbable suture for dermal closure. A running intracuticular 5-0 monofilament suture is used for skin closure. A small soft passive drain is used in the subcutaneous tissues, and a tight pressure dressing is used for 48 hours.

Sculpting the Auricular Framework

Thorough knowledge of normal auricular anatomy is essential to the creation of a precise framework. Formation of the well-known patterns of normal convexities and concavities of the external ear are dependent on (1) accurate framework fabrication and (2) coaptation of the overlying skin. Precise creation of the auricular framework is based on detailed knowledge of auricular anatomy and the ability to sculpt these shapes accurately.

Carving the auricular framework requires several No. 10 and No. 15 scalpel blades and sharp wood-carving tools. A set of wood-carving gouges can be purchased at any arts and crafts store and facilitates deepening of small areas, such as the triangular fossa, the scaphoid fossa, and the conchal bowl. Surgeons should hone their skills by practicing on a potato or an apple. In addition, observing an experienced microtia surgeon aids in developing a carving method.

The auricular framework body is first carved from the synchondrotic portion of the rib graft (Fig. 1-54A). The general size of the framework is first achieved by using a No. 10 scalpel blade (Fig. 1-54B). Further “gross” carving of the framework is accomplished with a No. 15 scalpel. The fine detail of the framework body is achieved by using curved and beveled gouges from the wood-carving set (Fig. 1-54C). Creation of maximal differential in heights between the framework and the carved areas allows maximal definition of the constructed ear postoperatively. The original template (cut from radiographic film) is used as a guide to ensure that the contours are located in the proper position. Occasionally, a small piece

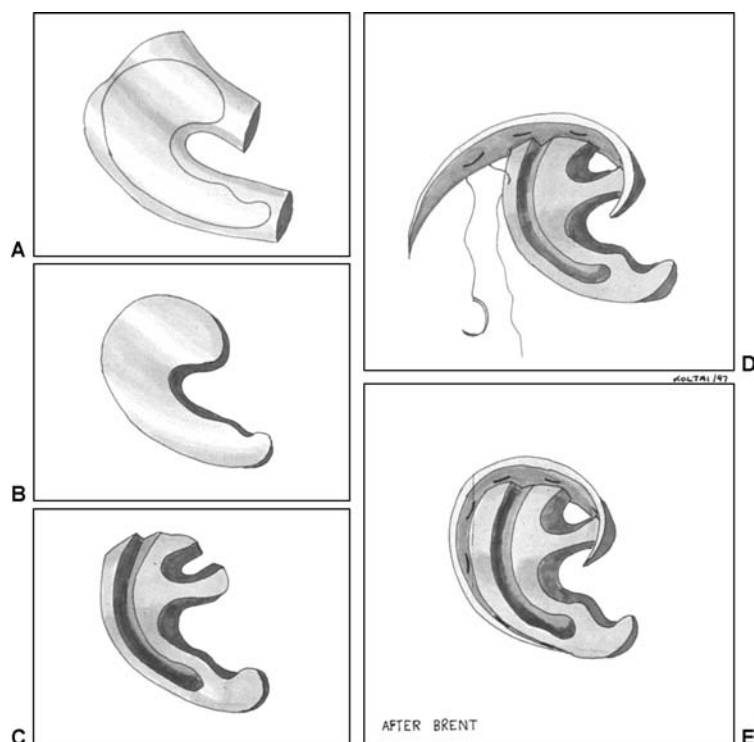


FIGURE 1-54 (A–C) Sculpting of the auricular framework body. (D,E) After sculpting and thinning of the auricular helix from the floating rib, it is affixed to the framework body with 4-0 monofilament permanent sutures. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

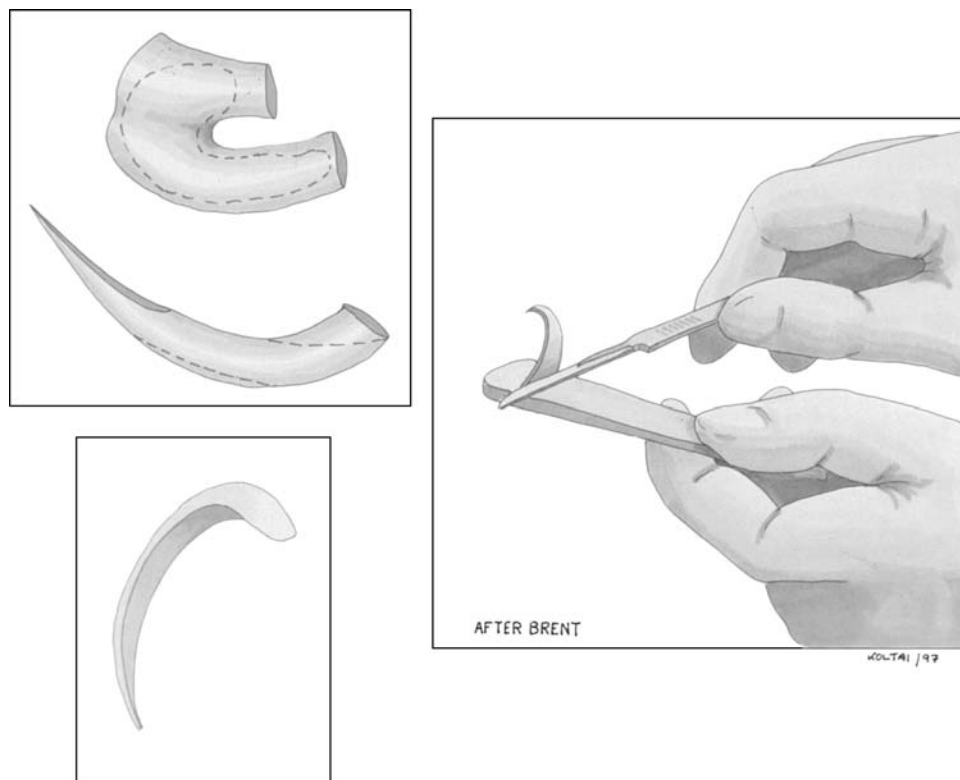


FIGURE 1-55 Thinning of the floating rib to create a curved appearance for the auricular helix. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

of cartilage is sutured to the framework to augment a desired area.

After the framework body is sculpted, the helix is carved from the floating rib. To create adequate flexion of the floating rib, this cartilage is carefully “thinned” using a No. 15 scalpel. Thinning of the floating rib is performed on the outer surface to facilitate bending in the opposite (inner) direction (Fig. 1-55). The helix is then affixed to the framework body with 4-0 clear monofilament permanent suture (Fig. 1-54D,E). Several horizontal mattress sutures are used for stability, with the knots being buried on the undersurface of the cartilage framework. Projection of the helix (lateral to the framework body) should be maximized. Augmentation of the helix (to increase lateral projection) is sometimes necessary and requires an additional cartilage graft sutured onto the undersurface of the affixed floating rib.

Placement of the Framework

After the auricular framework is sculpted and stabilized with sutures, placement of the framework into the skin pocket is performed. Additional thinning of the skin is achieved just prior to framework placement. Two self-contained petite vacuum drains are placed to prevent hematoma formation and to facilitate coaptation of the skin pocket. The drains are placed prior to placement of the framework and sutured into position. The framework is then positioned into the skin pocket and digitally

manipulated. If the skin pocket is too small, the graft is removed and the pocket dissection increased. The skin wound is then closed with 5-0 monofilament suture with the drains under maximal suction. After skin closure, the drains are carefully checked for any leaks in the system. The two suction drains are placed into vacuum tubes (tubes usually used for blood drawing) (Fig. 1-56).



FIGURE 1-56 Intraoperative appearance after placement of two suction drains and the auricular framework. Note that the lobule is malpositioned at this time. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1-57 Placement of a conforming dressing into the crevices of the newly created auricular framework. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

The nursing staff and family are carefully instructed on how to change tubes to maintain adequate suction on the overlying skin flap. This maximizes coaptation of the flap and definition of the newly constructed auricle. The

patient is usually discharged from the hospital with the drains in place.

The dressing after auricular reconstruction is very important. Strips of Vaseline-impregnated gauze are placed into the concavities of the constructed ear (Fig. 1-57). A dry pressure dressing with fluff gauze pads is then applied and left in place for 48 hours. The patient is maintained on oral antibiotics for 7 days, and the suction drains usually remain in place for 5 days. A protective head dressing is worn by the child for 4 weeks.

Stage 2: Lobule Transposition

Although some surgeons reposition the lobule remnant while placing the auricular framework, lobule transposition is more accurately performed as a second stage. This procedure is usually performed on an outpatient basis at least 3 months after cartilage graft placement. A modified transposition flap is designed to reposition the lobule posteriorly and inferiorly (Fig. 1-58). It is important to maintain a healthy base to the lobular transposition flap to ensure adequate vascularity of the flap. Dissection under the inferior aspect of the cartilage graft is accomplished and slight elevation of the graft. The lobule remnant is then filleted with a portion of this soft tissue being placed deep to the cartilage graft (Figs. 1-59 and 1-60). This creates bulk and support in this area of transposition and prevents depression of the scar. If soft tissue

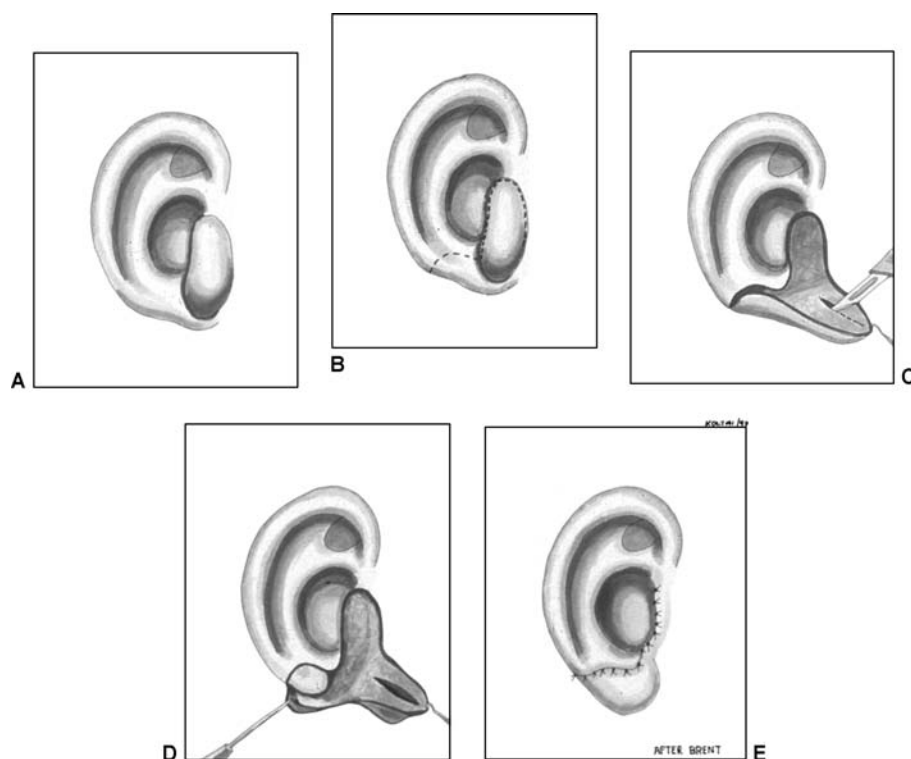


FIGURE 1-58 Schematic diagram of transposition of the lobule with filleting of the lobule. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1-59 Intraoperative view with filleting of the lobule and creation of a transposition flap. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1-60 Intraoperative view of transposition of the lobular remnant. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

support of this transition zone (between the framework and the native lobule) is not adequate, an unsightly depression is formed (Fig. 1-61). The subcutaneous soft tissues are sutured into position with 4-0 braided synthetic absorbable suture. Skin closure is accomplished with interrupted 5-0 monofilament sutures.

Stage 3: Lateralization of the Auricle (with Split-Thickness Skin Graft)

Although the overall size, shape, and configuration of the constructed ear is determined after the first two



FIGURE 1-61 Postoperative view after lobular transposition showing good position of the lobule but lack of soft tissue fullness in the area of the suture line. This creates an unsightly depression in the region of transposition. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

reconstructive stages, the ear usually lacks sufficient lateral projection at this point. This lack of projection occurs because the three-dimensional cartilage framework is placed into a two-dimensional skin-soft tissue pocket. To increase the auriculocephalic angle and create a postauricular sulcus, significant mobilization of the graft and placement of a postauricular skin graft is performed. Again, this procedure is performed at least 3 months after lobule transposition (or 6 months after placement of the original auricular framework).

A generous incision is made at the posterior margin of the graft from the superior helix to the lobule inferiorly (Fig. 1-62A). The graft is then dissected entirely from the head, leaving a layer of soft tissue on the posterior surface of the graft (Fig. 1-62B). The skin overlying the mastoid is then undermined and advanced anteriorly (Fig. 1-62C). At this point, a split-thickness skin graft (~15/1,000 inch thick) is harvested from the upper, outer thigh. The skin graft is then sutured onto the posterior aspect of the auricular framework (Fig. 1-62D). It is important to resurface the postauricular (mastoid) bone with skin advanced from the retroauricular scalp, rather than with harvested skin graft. The postauricular skin is undermined, advanced, and sutured into position with 3-0 braided synthetic absorbable suture. This deepens the sulcus, projects the ear, and prevents tethering of the reconstructed ear. A retroauricular bolster is placed (to define the sulcus) for 7 days (Fig. 1-62E).

Stage 4: Conchal Excavation and Tragal Reconstruction

After completion of the first three stages of microtia repair, the correct size, shape, orientation, and projection

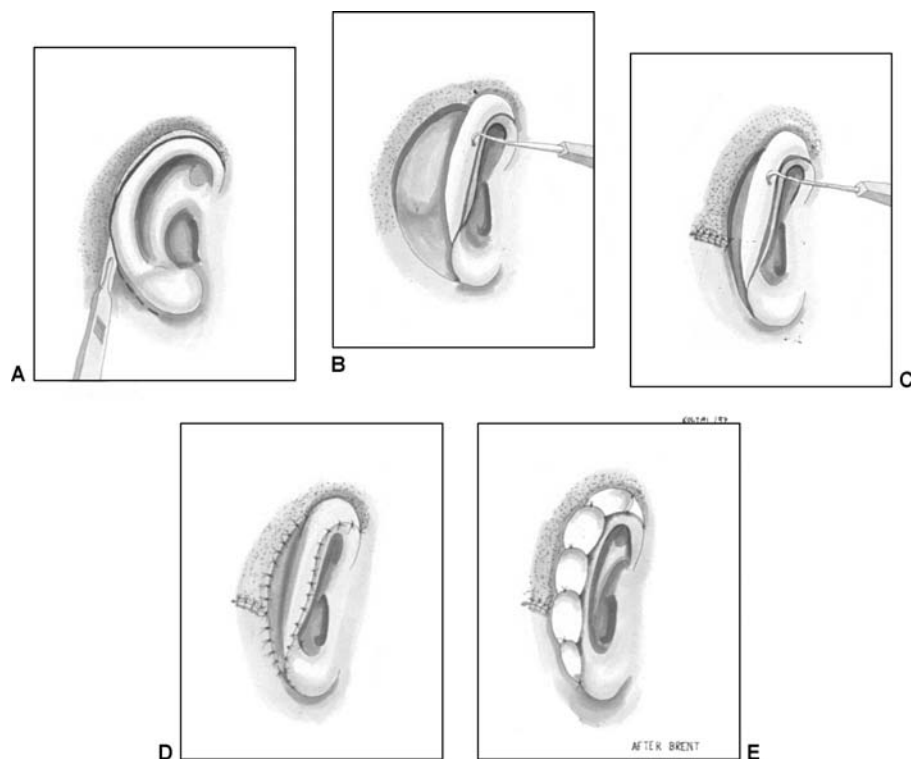


FIGURE 1-62 (A–D) Schematic diagrams showing lateralization of the auricle with advancement of postauricular skin and placement of a split-thickness skin graft on the posterior aspect of the auricle. (E) A bolster is then placed to ensure immobility of the graft. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

of the ear are obtained. At this point, many patients are satisfied and request no further surgical procedures. In motivated patients, however, a fourth stage can be performed that improves the definition and contour of the anterior ear.

A composite chondrocutaneous graft is harvested from the cymba concha of the opposite ear using a curved incision on the anterior surface of the ear. A J-shaped incision is made in the conchal bowl of the reconstructed ear, and the bowl is deepened by defatting the soft tissue from the conchal floor. The same curved J-shaped incision is used to both deepen the conchal bowl and to insert the composite graft for tragal reconstruction. The excavated concha is resurfaced with a small full-thickness skin graft from the opposite lobule, and the tragus is reconstructed with the composite graft from the opposite cymba concha. Vaseline-impregnated gauze is placed in the canal and on the conchal floor, and a pressure dressing is placed for 5 days.

SECONDARY AURICULAR RECONSTRUCTION

In many instances, the native skin envelope will not be of sufficient quality to support a successful microtia repair. Lack of sufficient skin may result from prior trauma to the auricular skin, or from a prior failed attempt at microtia repair. Failed auricular reconstruction is usually caused by infection, hematoma, or extrusion of an alloplast

or auricular autograft. In any case, the overlying skin covering is crucial to the final reconstruction, and poor vascularity of the skin significantly compromises the result (Fig. 1-63).



FIGURE 1-63 Example of a poor result from an auricular reconstruction. Poor vascularity and thickness of the overlying skin prevented sufficient auricular detail. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

In cases with insufficient skin covering, elevation of a pedicled temporoparietal fascia flap (TPFF) can be used to cover the auricular framework graft.¹³⁹ The TPFF is a thin, well-vascularized transposition flap proximate to the operative field (Fig. 1–64).¹⁴⁰ It has a hearty blood supply that serves as a rich bed to support a split-thickness skin graft.

The temporoparietal fascia (TPF) is located in the temporal region deep to the subcutaneous tissue and superficial to the deep temporal fascia. It is supplied by the superficial temporal artery (one of the two terminal branches of the external carotid artery) and vein. Other important structures that travel within the TPF include the auriculotemporal nerve and the frontal branch of the facial nerve. The TPF is an extension of the superficial musculoaponeurotic system fascia of the lower face and is continuous with the galea aponeurosis of the forehead and scalp. The TPF is densely adherent to the overlying skin but loosely connected to the underlying deep temporal fascia by loose areolar tissue between the facial layers. This areolar tissue allows the TPF to slide on the deeper fascial layers.

Elevation of the Temporoparietal Fascia Flap

When performing secondary auricular reconstruction, a TPFF is outlined large enough to drape over the

entire auricular framework. After removal of the poorly vascularized skin and auricular remnant, a hemicoronal scalp incision is made superficially into the subcutaneous tissue of the scalp. It is important that the surgeon not violate the TPFF, which is located superficially. Sharp elevation of the skin and subcutaneous tissue is accomplished using a No. 10 scalpel in a meticulous fashion. This densely adherent plane is unnatural, and the dissection is time-consuming.

After skin elevation, the vascular TPF layer can be visualized. A rectangular TPFF is then outlined and marked. Care must be taken not to transect the frontal branch of the facial nerve with the anterior limb of the TPFF. The location of this nerve should be marked on the patient to avoid transaction. The course of the frontal branch can be outlined by drawing a line between the external auditory canal and a point 2 cm above the lateral eyebrow. If the anterior limb of the outlined TPFF is posterior to the course of the frontal branch of the facial nerve, injury to the nerve will be avoided.

Dissection of the flap off the deep temporal fascia is easily accomplished in a blunt fashion. Transposition of this flap is performed by turning the flap 180 degrees inferiorly, after the new auricular framework graft is secured in position with periosteal fixation sutures (4-0 monofilament absorbable sutures) (Fig. 1–65). The



FIGURE 1–64 Intraoperative photograph of an elevated temporoparietal fascia flap prior to transposition. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1–65 Transposition of a temporoparietal fascia flap in a secondary auricular reconstruction. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)



FIGURE 1-66 Intraoperative view of a secondary auricular reconstruction after transposition and attachment of a temporo-parietal fascia flap (TPPF). The new auricular framework has been positioned underneath the TPPF and is awaiting placement of a split-thickness skin graft. (From Cotton RT, Myer CM. *Practical Pediatric Otolaryngology*. Philadelphia: Lippincott-Raven, 1999, with permission.)

TPPF/auricular framework sandwich is then covered with a split-thickness skin graft (Fig. 1-66). Dressings and drains are performed as with primary microtia repair. Dressings are kept in place for 48 hours, and drains are usually left in for 4 to 5 days.

DENTOFACIAL DEFORMITIES

The evaluation of any face should include both skeletal and soft tissue analysis. Skeletal analysis of the face involves evaluation of the facial bones and teeth. Soft tissue analysis can be done by careful, focused observation and can be aided by the study of frontal and lateral patient photographs.

Many children develop less than ideal dental occlusion. Treatment of this malocclusion usually can be achieved with orthodontic appliances. However, some malocclusion is associated with facial skeletal deformities that require both orthodontics to realign the dental arches and surgery to reposition the upper and lower dental arches. To accurately treat a patient with both skeletal and dental abnormalities, a detailed analysis

of the face and systematic treatment plan must be performed.

The treatment goals in any patient with secondary dentofacial deformities are the establishment of a complete, functional maxillary dental arch; a stable, functional occlusion; and balanced facial aesthetics.¹⁴¹ Surgical correction of dentofacial deformities aids in creating balanced proportion of facial features.

DENTAL ANALYSIS

The establishment of balanced facial proportions begins with good dental occlusion. Occlusion is the relationship of the maxillary to the mandibular teeth. This relationship largely depends on the relative position and angulation of the teeth to each other. Malocclusion refers to a dental relationship that is less than optimal. It can result from dental or skeletal deformities, or a combination of both.

In 1899 Angle¹⁴² developed a classification system to describe normal and abnormal dental occlusion. The reference point in the Angle classification is the relationship of the maxillary to the mandibular first molar teeth. Each molar tooth has four grinding surfaces, called *cusps*. The surfaces adjacent to each cusp are referred to as *grooves*. Cusps adjacent to the tongue are called *lingual*, and those adjacent to the cheek are called *buccal*. Cusps located anteriorly, or toward the midline, are referred to as *mesial*, and those situated posteriorly, or away from the midline are called *distal* (Fig. 1-67).

There are three general categories of occlusion in the Angle classification system. In class I occlusion, the mesial buccal cusp of the first maxillary molar fits in

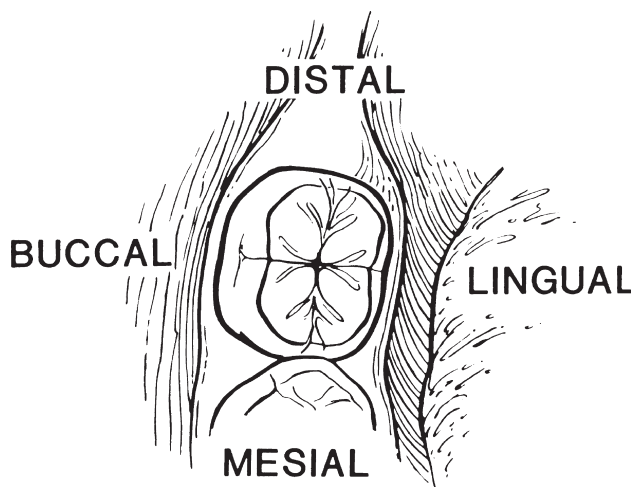


FIGURE 1-67 Orientation of molar cusp. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

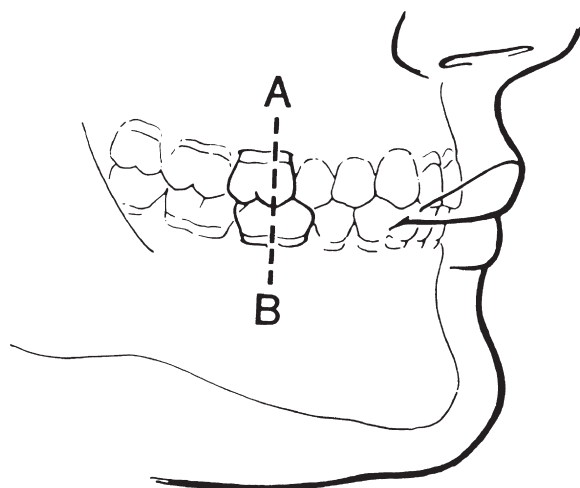


FIGURE 1-68 Schematic diagram of class I molar occlusion. (A) The mesial buccal cusp of the first maxillary molar. (B) The buccal intercuspal groove of the mandibular first molar. (From Papell ID. Facial Plastic and Reconstructive Surgery, 2nd ed. New York: Thieme, 2002, with permission.)

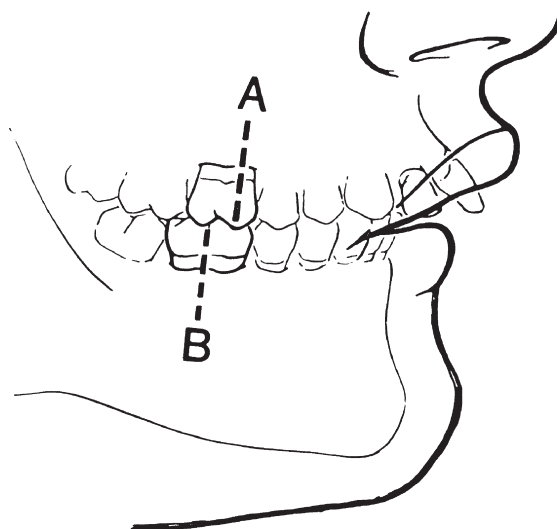


FIGURE 1-69 Schematic diagram of class II malocclusion. (A) The mesial buccal cusp of the first maxillary molar. (B) The buccal intercuspal groove of the mandibular first molar. (From Papell ID. Facial Plastic and Reconstructive Surgery, 2nd ed. New York: Thieme, 2002, with permission.)

the groove on the lateral or buccal surface of the first mandibular molar tooth (Fig. 1-68). However, this represents only the ideal relationship of the molar teeth. When the remainder of the teeth interdigitate perfectly, the occlusal relationship is said to be normal. Malocclusion can exist when the molar relationship is class I. This type of malocclusion is generally less severe and usually based on dental rather than skeletal deformities. Although the molar relationship is normal, crowding of the anterior teeth may occur. Another variation of class I malocclusion occurs when there is bimaxillary protrusion. In this situation the mandibular length is excessive, causing a protrusion of both upper and lower incisor regions.

Class II malocclusion is skeletally and dentally based. The mesial buccal cusp of the first maxillary molar is mesial, or in front of the first mandibular molar (Fig. 1-69). There are two subtypes of class II occlusion. In the more common subtype, division 1, there is excessive overjet (anterior maxillary protrusion), and the maxillary incisors are quite protrusive. In division 2 there is a deep bite (overbite) with the maxillary incisors overlapping and covering the mandibular front teeth by more than the usual amount (Fig. 1-70). In class II, division 2 occlusion, there is a posterior tilting of the central incisors and a flaring of the lateral incisors. A deep bite is present, but overjet is not as pronounced.

Class II malocclusion may arise from a lack of mandibular development. The resulting posteriorly positioned mandible is termed *retrognathia*. This condition often prevents the upper lip from completely covering the upper incisor teeth. Lack of complete lip seal exposes

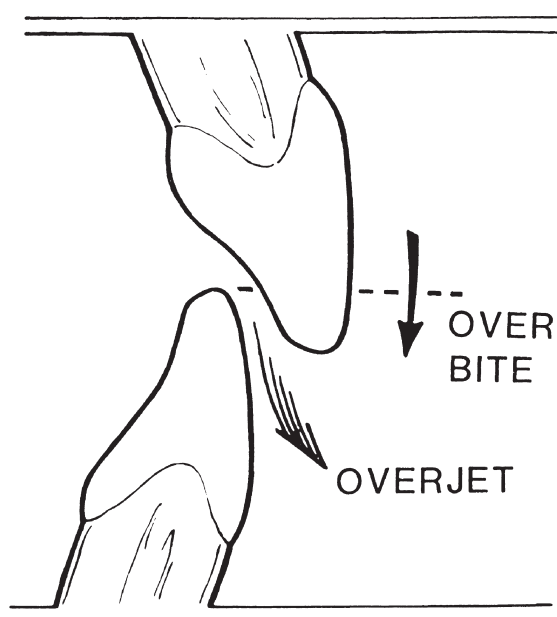


FIGURE 1-70 Relationship of the central mandibular and maxillary incisors. The difference between overbite and overjet is indicated. (From Papell ID. Facial Plastic and Reconstructive Surgery, 2nd ed. New York: Thieme, 2002, with permission.)

the upper incisors, rendering them more vulnerable to injury. A class II molar relationship may also arise from an abnormally protuberant maxilla.

Class III malocclusion is primarily skeletally based. It is characterized by a large protrusive mandible or an underdeveloped, retrusive maxilla. The mesial buccal

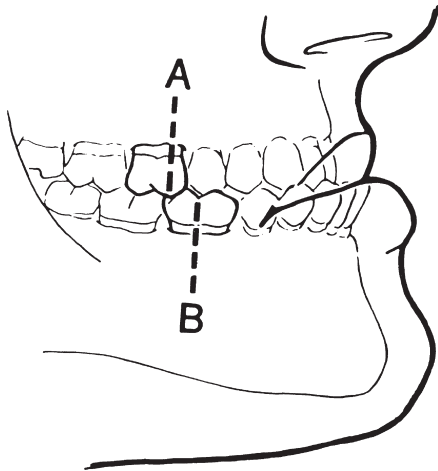


FIGURE 1-71 Schematic diagram of class III malocclusion. (A) The mesial buccal cusp of the first maxillary molar. (B) The buccal intercusp groove of the mandibular first molar. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

cusp of the first maxillary molar is positioned distal to its ideal position (Fig. 1-71). Protrusion of the mandible is called *prognathia*.

In addition to anteroposterior malocclusions, suboptimal relationships can exist in a medial-to-lateral direction. The ideal relationship occurs when the buccal cusps of the maxillary molar teeth are just lateral to the opposing mandibular buccal cusps. If the maxillary and mandibular molar cusps contact end-to-end or the maxillary buccal cusps are medial to their mandibular counterparts, a lingual cross-bite is present. If the maxillary teeth are more lateral than is ideal, a buccal cross-bite exists (Fig. 1-72).

Malocclusion can thus result from dental or skeletal abnormalities or a combination of both. The cause of malocclusion may be congenital, traumatic, or a

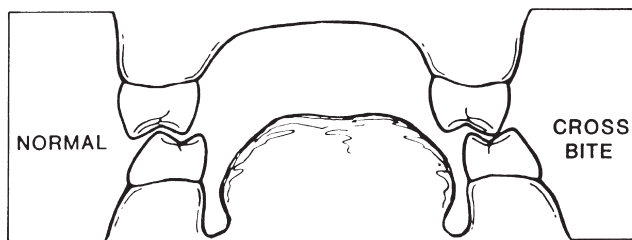


FIGURE 1-72 Schematic diagram of the coronal view of the oral cavity at the level of the first molar teeth. (Left) A normal molar relationship is shown with the maxillary buccal cusp related to the buccal surface of the underlying mandibular molar. (Right) A lingual crossbite is indicated. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

consequence of extirpative surgery for neoplastic disease.¹⁴³ The dentofacial deformities produced may cause both cosmetic and functional problems. These include difficulties with speech, mastication, and swallowing. It is therefore imperative that the facial plastic surgeon carefully address the occlusal relationships when treating any facial deformity.

SKELETAL ANALYSIS

Analysis of the facial skeleton involves evaluating each of the facial bones in its relationship to another, and evaluation of these bones with their relationship to the cranium. Cephalometry, the scientific measurement of the dimensions of the head, has been used to assess the craniofacial growth and is based on precise radiographs of the craniofacial skeleton. Radiographs of the facial skeleton are achieved by using a special head holder known as a cephalostat, which holds the head in a fixed and reproducible position (Fig. 1-73).^{144,145}

The standardized cephalometric radiograph produced provides a two-dimensional outline of the lateral aspect of the craniofacial skeleton. A careful cephalometric tracing of this X-ray provides objective data that assist in

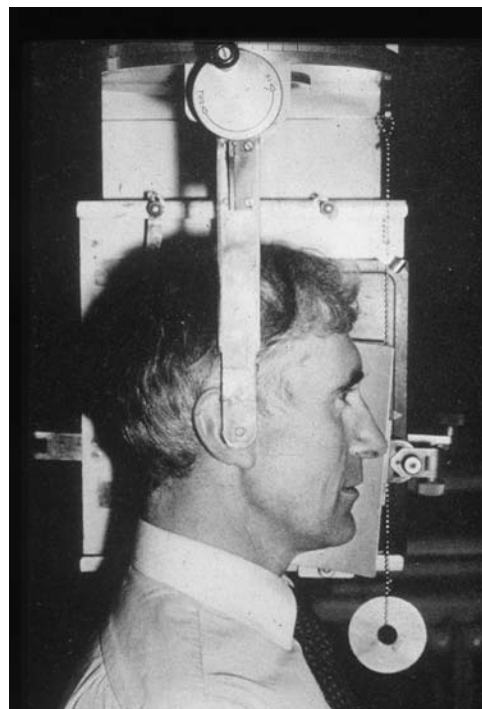


FIGURE 1-73 The cephalostat holds the head in a fixed and reproducible position. Two rods are positioned in each external auditory meatus and a Lucite bar rests passively at the nasion. The x-ray cassette is positioned at the patient's left at a constant distance from the midline from the cephalostat and the head. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

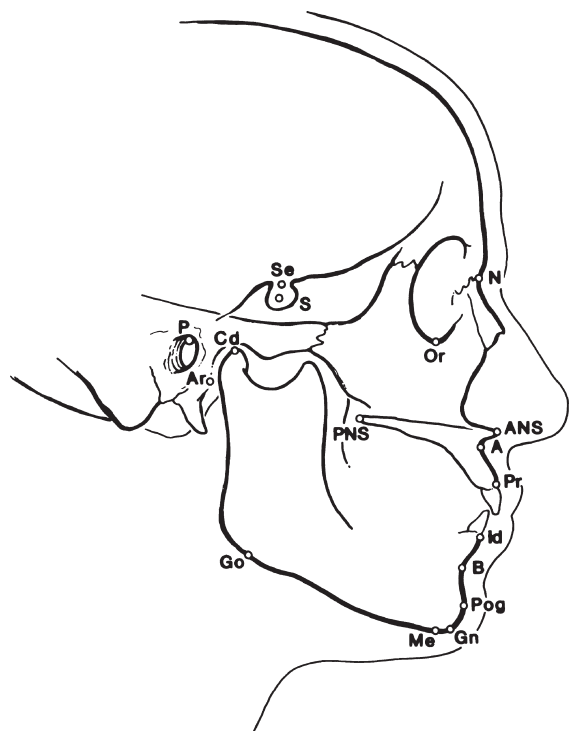


FIGURE 1-74 Schematic diagram of the commonly used skeletal reference points in cephalometric analysis. N, nasion; S, sella; A, subspinale; Pr, prastion; B, supramentale; Id, infraorbitale; Pog, pogonion; Gn, gnathion; Me, menton; Go, gonion; Cd, condylion; Ar, articulare; ANS, anterior nasal spine; PNS, posterior nasal spine; OR, orbitale; P, porion. (From Rakowski T. *An Atlas and Manual of Cephalometric Radiography*. Philadelphia: Lea & Febiger, 1982, with permission.) (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

the diagnosis and treatment of dentofacial and facial skeletal deformities.¹⁴⁶

The cephalometric radiograph allows identification of specific facial skeletal reference points (Fig. 1-74). These soft tissue and skeletal reference points can be used to identify various cephalometric reference lines. The *Frankfort horizontal plane* is based on a line joining the superior border of the external auditory canal (porion) with the inferior border of the infraorbital rim (infraorbitale) (Fig. 1-75). The Frankfort horizontal plane is used as a reference when orienting medical photographs of patients.

Identification of standardized bony reference points and lines allows linear and angular measurements to be determined.¹⁴⁷ These measurements can be compared with normative reference values. Deviation from these normals allows quantitation of the skeletal abnormality. Angles SNA, SNB, and ANB (in which S stands for sella, N for nasion, A for subspinale, and B for supramentale) are relatively simple to determine and provide valuable basic information in analyzing the relationship of the maxilla and mandible (Fig. 1-76).¹⁴⁷ These angles have a narrow range of normal values. Analysis of these angles

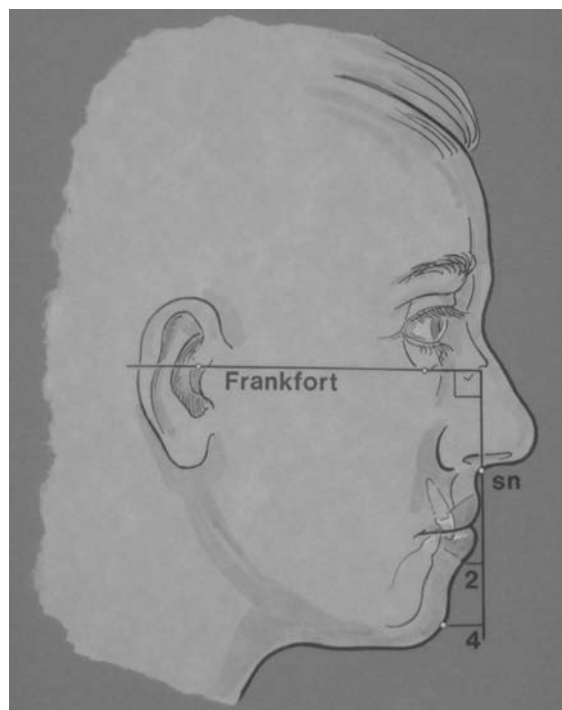


FIGURE 1-75 The Frankfort horizontal plane. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

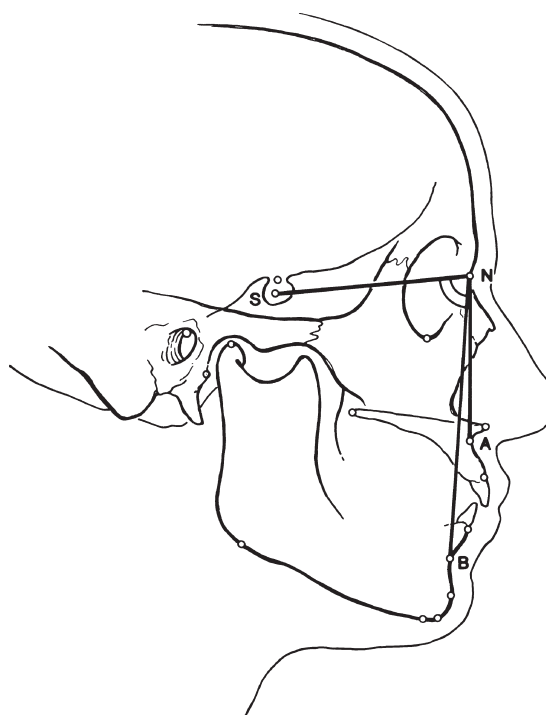


FIGURE 1-76 Cephalometric angular measurements. SNA, SNB, and ANB: these reference angles have a narrow range of normal values. S, sella; N, nasion; A, subspinale; B, supramentale. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

allows evaluation of the maxillary versus mandibular contribution to a given malocclusion. For example, if the angle ANB is greater than 4° , a skeletal class II malocclusion is present. If ANB is greater than 4° and SNA is greater than normal, then class II malocclusion is most likely secondary to maxillary protrusion. If ANB is greater than 4° and SNA is less than normal, mandibular retrognathia probably exists.

SOFT TISSUE ANALYSIS

The overall form and structure of the human face is a product of many factors.¹⁴¹ Dental analysis and treatment directly address the relationship of the maxillary and mandibular teeth. Skeletal analysis demonstrates the relationship of the facial bones and illustrates any deformity in this relationship. However, dental and skeletal analyses alone are inadequate in evaluating and predicting facial form. Assessment of the soft tissues is crucial in preoperative facial analysis and in achieving harmonious facial balance after surgery.

Soft tissue analysis is the final determinant in evaluating the overall attractiveness of the face. It is the method used by the casual observer and therefore is generally more subjective and less easily quantified. However, the facial plastic surgeon must be able to set some standards of facial beauty; the casual observer also does this, but in an unstructured manner. Successful correction of dento-facial deformities requires careful preoperative evaluation of soft tissues and accurate prediction of their response to skeletal surgery. Although the soft tissues are more difficult to standardize than dental or skeletal parameters, analysis may be performed by using fixed soft tissue reference points. These points are often direct correlates of associated bony reference points (e.g., *n* = soft tissue correlate to the skeletal nasion [*N*]; *pog* = soft tissue pogonion [*Pog*].) However, they also represent soft tissue points that are variable in their location and have no fixed skeletal correlate (e.g., the trichion [*tr*] or hairline). It is the variable thickness of the soft tissues (e.g., skin of the lips or nose) and the relative position of nonfixed points (e.g., the trichion) that determine the overall facial structure and appearance.

The soft tissue reference points can be used to determine various lines and to calculate various angular measurements. This can be done in a similar manner to the cephalometric bony linear and angular measurements. The soft tissue points can also be used to analyze vertical facial height. In this analysis, the distance from the trichion (*tr*) to the gnathion (*gn*) may be subdivided into thirds by the nasion (*n*) and subnasale (*sn*) soft tissue points (Fig. 1-77). Because hairlines are variable, the upper third of the face is not usually a reliable measurement. However, the middle and lower thirds of the face are reliable and should approximately form a 1:1 ratio. Ratios greater than 1 indicate vertical maxillary excess, foreshortening of the

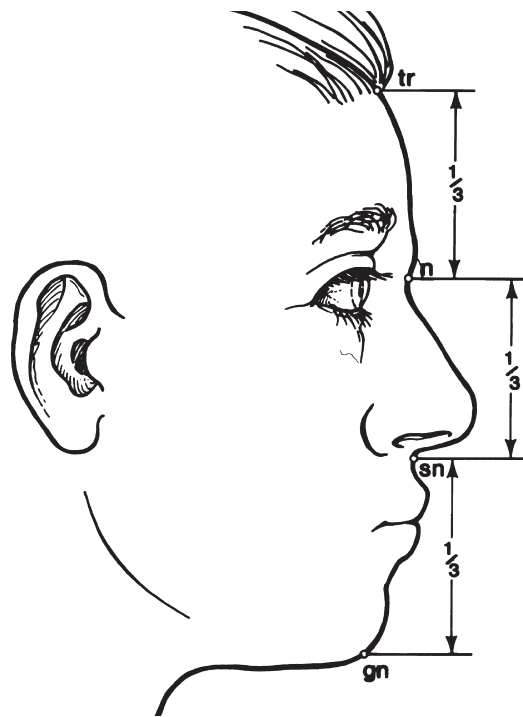


FIGURE 1-77 Vertical facial heights. Balanced facial proportions allow the face to be broken up into three relatively equal thirds. The upper facial third from the trichion (*tr*) to the nasion (*n*) is the most variable as the hairline is often quite variable in individuals. A 1:1 ratio should exist between the middle and lower facial thirds. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

lower third of the face, or a combination of these elements. A vertical height ratio of less than 1 signifies a large lower facial third or vertical maxillary deficiency.

The lower third of the face may be further subdivided into two segments (Fig. 1-78). This allows further analysis of the soft tissues of the upper lips, lower lips, and chin.¹⁴⁸ The position and posture of the lips is determined by the dental and skeletal support and must be included in any complete evaluation of the lower third of the face. The upper lip length (from subnasal [*sn*] to stomion superius [*sto^s*]) should be approximately one half of the lower lip length (from stomion inferius [*stoⁱ*] to gnathion [*gn*]). When the ratio of the upper to lower lip is smaller than 1:2, the vertical height of the lower lip and chin is excessive and a vertical reduction genioplasty may be indicated. Various other analyses have been developed for evaluating lip and chin position.^{149,150} These analyses illustrate wide variation in the normal relationship between the teeth, lips, and chin. Lip and chin projection are perhaps best evaluated by drawing a vertical line from subnasal (*sn*) to pogonion (*pog*).

To accurately correct facial deformities, the facial plastic surgeon must understand the amount of soft tissue

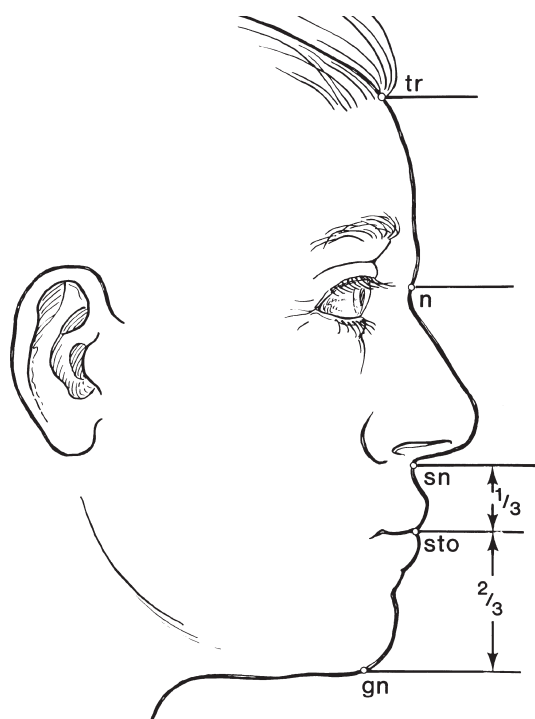


FIGURE I-78 Lower facial height. A ratio of 1:2 should exist between the height of the upper lip and height of the lower lip and chin. sn, subnasale; sto, stomion. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

change gained by a given bony alteration. It is certainly clear that soft tissue responses to skeletal surgery vary in different regions of the face. It is the accurate prediction of these responses that determines the final aesthetic result.

In portions of the face where the overlying soft tissues are relatively thin, larger, and more predictable, soft tissue changes are usually obtained for a given bony alteration.¹⁵¹ Additionally, different procedures on a given facial skeletal area may produce different soft tissue responses. For instance, mandibular advancement procedures increase the soft tissues in a 1:1 ratio at the chin and approximately a 0.8:1 ratio at the lower lip.^{152,153} When augmentation genioplasty is used for less significant microgenia, the soft tissue response at the pogonion is ~0.8:1.¹⁵³ When augmentation genioplasty is used as an adjunct to mandibular advancement, the additional soft tissue advancement as a result of the genioplasty is only 0.4:1 (response ratio).¹⁵³ Similar response ratios of soft tissue to bony changes can be measured for mandibular setback surgery, and maxillary advancement and setback surgery.¹⁵¹ Although these ratios are not absolute, they can be used as a guide to predict the particular soft tissue response to surgery on a particular portion of the facial skeleton.

The overall appearance after correction of a facial deformity is therefore a result of both the skeletal correction and the redraping of the overlying skin/soft tissue envelope. This fact has been well understood by surgeons who perform cosmetic rhinoplasty, where changes in the

infrastructure of the nasoskeleton may be minimized or accentuated depending on the relative skin thickness.

TREATMENT PHILOSOPHY

After performing a thorough dental, skeletal, and soft tissue analysis, a complete problem list of the dentofacial deformity is compiled. This problem list should include all medical or systemic problems, dental occlusal problems, and problems relating to the facial skeleton. In addition, any soft tissue abnormalities are identified. The problem list may then be prioritized according to the severity of each particular deformity.

A systematic treatment plan for the patient with facial disharmony may then be established. The final treatment plan and goals should be thoroughly discussed with the patient. Most treatment plans for the patient with a dentofacial deformity involve complex and lengthy treatment, involving significant patient cooperation and commitment.¹⁵⁴ After careful analysis and systemic treatment planning are performed, surgical correction of the specific dental facial deformity is performed and facial harmony reestablished.

PREOPERATIVE ORTHODONTIC TREATMENT

All routine dental care should be completed before initiating orthodontic or orthognathic surgical treatment. This is important because orthodontic treatment and maxillomandibular fixation places considerable demands on the teeth and periodontal tissues. All dental caries, abscesses, and other inflammatory disease should be diagnosed and treated. Placement of crowns or treatment of missing teeth is usually postponed until orthodontic and orthognathic treatment is completed.

In most instances, preoperative orthodontic treatment is necessary to align the dental arches. The length of treatment of orthodontics is variable, but usually requires about 9 to 18 months. This treatment may require dental extractions to accommodate tooth movements and eliminate crowding.

The orthodontist should work closely with the maxillofacial surgeon to anticipate the postoperative position of the dental arches.^{155–157} Alignment of the dental arches in preparation for orthognathic surgery may decompensate the dental occlusion. For instance, in a patient with significant preoperative class II malocclusion, the maxillary and mandibular teeth may have become angulated to facilitate mastication. Proper orthodontic treatment in this patient is different when the patient is receiving orthodontics alone versus when the patient is having both orthodontic treatment and eventual orthognathic surgery. Orthodontic treatment in the patient with significant class II malocclusion will likely decompensate the bite and increase the dental discrepancy (Fig. 1–79). This dental decompensation is acceptable in the patient who is going to have subsequent orthognathic surgery to improve facial aesthetics.

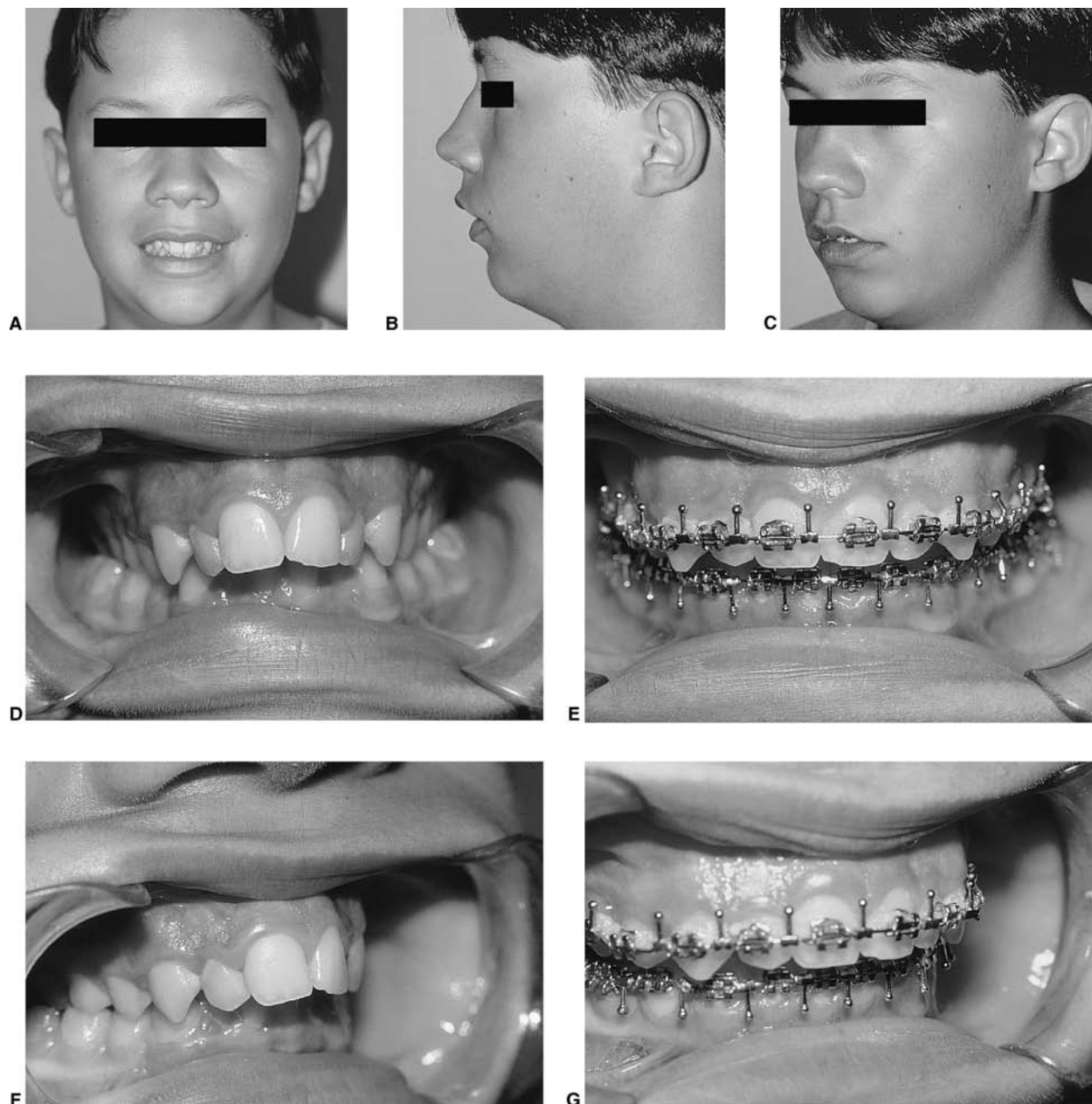


FIGURE I-79 (A–C) A 15-year-old boy with class II malocclusion, maxillary constriction, and retrognathia. (D,F) Preorthodontic occlusal views of the patient. (E,G) Postorthodontic occlusal views of orthodontic therapy. The patient ultimately underwent mandibular advancement and advancement genioplasty. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

Plaster dental models are constructed and these models are placed on an articulator (Fig. 1–80). An *articulator* consists of two metal platforms that are hinged on one end to simulate the temporomandibular joint. This enables the two models to slide on each other and allows evaluation of the movement necessary to achieve class I occlusion. A *facebow* may also be used to improve the analysis of the occlusion. The facebow allows further examination of the relationship of the maxilla to the anterior cranial base. A plan should be made by the orthodontist to

establish the maximal preoperative occlusal relationship in preparation for orthognathic surgery.

PREOPERATIVE WORKUP AND MODEL SURGERY

After maximal preoperative occlusal relationships are obtained, the plaster dental models are mounted and the amount of surgical correction is determined. An acrylic, interocclusal wafer splint is used during surgery. It provides an exact template on which the maxillary and mandibular dental arches may fit at the time of surgery.

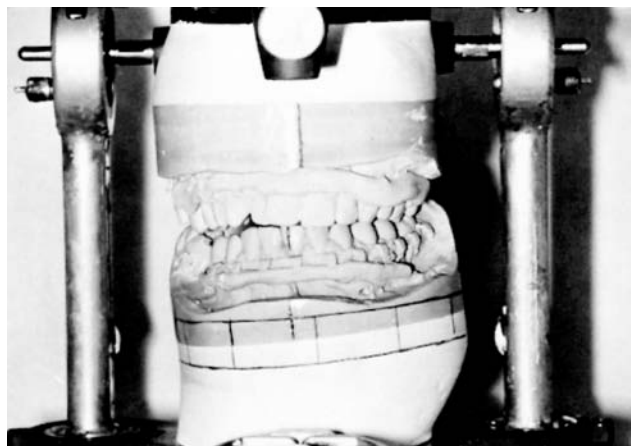


FIGURE 1-80 Anteroposterior view of plaster dental models mounted on an articulator. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

If a single-jaw surgery is to be performed, a single interdental wafer splint is placed at the conclusion of the jaw movement. The patient is then placed in maxillomandibular fixation (MMF) with the wafer splint in position. If surgery involves both the maxilla and mandible, two splints are fabricated prior to surgery (Fig. 1-81). The first splint (intermediate) is placed to indicate the position of the maxilla after movement, but prior to mandibular osteotomy. The second splint (final) is used to identify the occlusion and jaw position after both the maxillary and mandibular osteotomies and movements have been completed. This final splint remains in place after repositioning of the entire maxillo-mandibular complex.

The interdental wafer splint is constructed to indicate the *horizontal* (anteroposterior) and *transverse* new position of both jaws after osteotomy and repositioning. However, the interdental splint does not dictate the new *vertical* (superior-inferior) position of the jaws. The vertical dimension is determined during presurgical planning and is accomplished by osteotomy (for shortening) and bone grafting (for lengthening) prior to final bony movement.

In cases of complex maxillary osteotomies, a splint with full palatal coverage (rather than a wafer splint) is constructed. The full palatal coverage splint enhances stability after bony osteotomy and movement. This type of splint would be used in a patient with maxillary transverse constriction. After a paramedian palatal split, a full palatal coverage splint would be placed.

The initial plan for correcting any dentofacial deformity should include the type of surgery, the amount of jaw movement planned, and whether the deformity is best treated with one- or two-jaw surgery. This treatment plan should specifically address the patient's problem list, and the plan dictates surgical treatment.



FIGURE 1-81 Fabricated dental splints for patient undergoing two-jaw orthognathic surgery. The intermediate splint (above) is used after osteotomy, movement, and fixation of the maxilla and prior to mandibular osteotomy. The final splint (below) is used after both jaws are osteotomized, moved and fixated. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

MANDIBULAR PROGNATHISM

Various surgical procedures exist for correction of mandibular prognathism, including the vertical-subcondylar osteotomy and the sagittal-split osteotomy.¹⁵⁸ The vertical-subcondylar osteotomy may be performed through either an intraoral or extraoral approach, whereas the sagittal-split osteotomy is usually done intraorally. Each approach and technique has specific advantages and disadvantages. The procedure chosen should be individualized for the specific needs of the patient.

The vertical-subcondylar osteotomy was first performed by Caldwell and Letterman in 1954.¹⁵⁹ Several modifications of the original procedure, which was performed through an external incision, have been made.^{158,160} The major advantage of the vertical-subcondylar osteotomy is in avoiding injury to the inferior alveolar nerve. It may be performed through an intraoral or external incision. The intraoral approach has the advantage of avoiding the external cervical scar and the associated potential injury to the marginal mandibular branch of the facial nerve. However, the intraoral approach is technically more difficult. The more oblique the angulation of the mandibular rami in relation to the sagittal plane, the easier the exposure through the intraoral approach. The vertical subcondylar osteotomy is performed through a mucosal incision in the gingivobuccal sulcus from the base of the coronoid to the second

bicuspid. Care should be taken to avoid the buccal fat pad. Incision of the periosteum over the anterior aspect of the ramus is accomplished, and the periosteum is elevated posteriorly. The antilingual process is then carefully identified. This landmark is crucial because it is opposite the lingula, which is the entrance of the inferior alveolar neurovascular bundle on the medial aspect of the mandible.

The oblique osteotomy line is carefully marked from the sigmoid notch to the angle of the mandible. This line should be posterior to the antilingual process to avoid injury to the neurovascular bundle. The mandible is then scored with a cutting burr and the osteotomy completed with a reciprocating saw. After the osteotomy is performed bilaterally, the proximal segments are reflected laterally and the distal segment is allowed to recess medially (Fig. 1-82).

Occlusion is checked and the interocclusal wafer splint placed. Maxillomandibular fixation is applied and maintained for 6 to 8 weeks. Sometimes rigid fixation of the mandibular segments is used, alleviating the need for maxillomandibular fixation.

The external approach for the vertical-subcondylar osteotomy has the disadvantage of a cervical scar and the potential for injury to the marginal mandibular branch of the facial nerve. It is the preferred approach for setbacks of greater than 10 mm and for asymmetrical setbacks. It is performed through a 3-cm cutaneous incision in the relaxed skin tension lines approximately one

fingerbreadth below the angle of the mandible. Exposure and subperiosteal dissection are performed in a similar manner to the intraoral approach.

The sagittal-split ramus osteotomy (SSRO) of the mandible was first introduced by Obwegeser and Trauner in 1955.¹⁶¹⁻¹⁶³ Modified by Dal Pont in 1961,¹⁶⁴ it is a versatile procedure for correction of mandibular deformities because it can be used for both advancement and setback of the mandible. It is especially satisfactory when used in prognathic patients with an open-bite deformity. It is also well suited for rigid fixation.

A risk of the sagittal-split osteotomy is inferior alveolar nerve injury. The procedure is also associated with avascular necrosis of the proximal bony segment. The teeth adjacent to the sagittal fracture line may also be compromised during the SSRO.

The sagittal-split osteotomy is done intraorally through a mucosal incision similar to that of the vertical-subcondylar osteotomy. Subperiosteal dissection is performed on both the medial and lateral surfaces of the mandible. The lingual and mandibular foramina are identified on the medial surfaces of the mandible. A horizontal osteotomy is made on the medial cortex 5 mm above the lingula. A vertical segment of bone is then removed from the anterior aspect of the proximal lateral bony segment. The width of the segment to be removed should equal that of the setback to be achieved (Fig. 1-83).

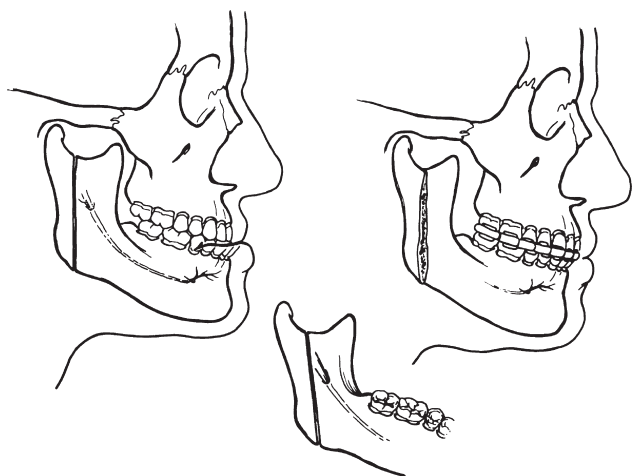


FIGURE 1-82 Schematic diagrams of the vertical subcondylar osteotomy. The oblique osteotomy line is made from the sigmoid notch to the angle of the mandible. This osteotomy is posterior to the inferior alveolar neurovascular bundle. After bilateral osteotomies are performed, the proximal segments are reflected laterally and a mandibular setback is accomplished. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

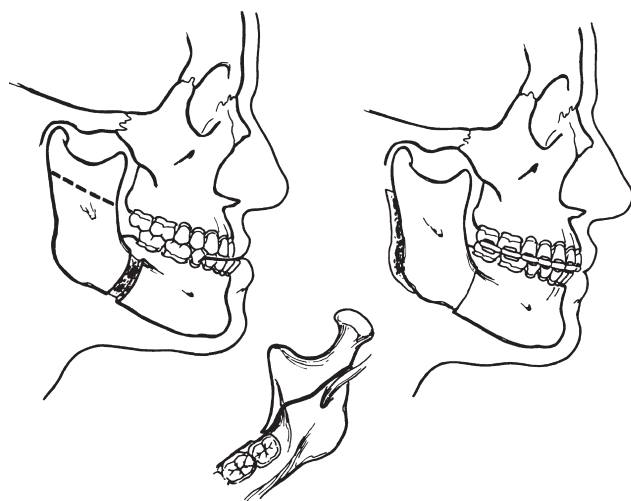


FIGURE 1-83 Schematic diagrams of the sagittal-split osteotomy. This osteotomy consists of a horizontal osteotomy on the medial cortex 5 mm above the lingula. A second vertical osteotomy is made through the lateral cortex in the region of the second molar tooth. The sagittal split is completed by connecting the two osteotomies along the oblique line. The inferior alveolar neurovascular bundles remain medially with a distal segment. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

The contralateral osteotomy is then accomplished in a similar manner, and occlusion is obtained with a wafer occlusal splint. The proximal segments are carefully positioned in each glenoid fossa. Maxillomandibular fixation is again placed for 6 to 8 weeks.

The sagittal-split osteotomy is a versatile procedure for mandibular deformities. The distal (i.e., tooth-bearing) segment may be retruded, advanced, or rotated to close an anterior open bite (Fig. 1–84). It is also the procedure of choice in patients requiring two jaw surgeries. The wide surface contact between the proximal and distal segments

ensures rapid bone healing; delayed union and nonunion are extremely rare. The main disadvantage of this procedure is the incidence of permanent anesthesia of the lower lip, with reports as high as 45%.¹⁶⁵

MANDIBULAR RETROGNATHISM

Retrognathism, or mandibular deficiency, defines a group of conditions in which the mandible is small, retruded, or both. The occlusion in retrognathism is class II and this malocclusion is generally skeletally

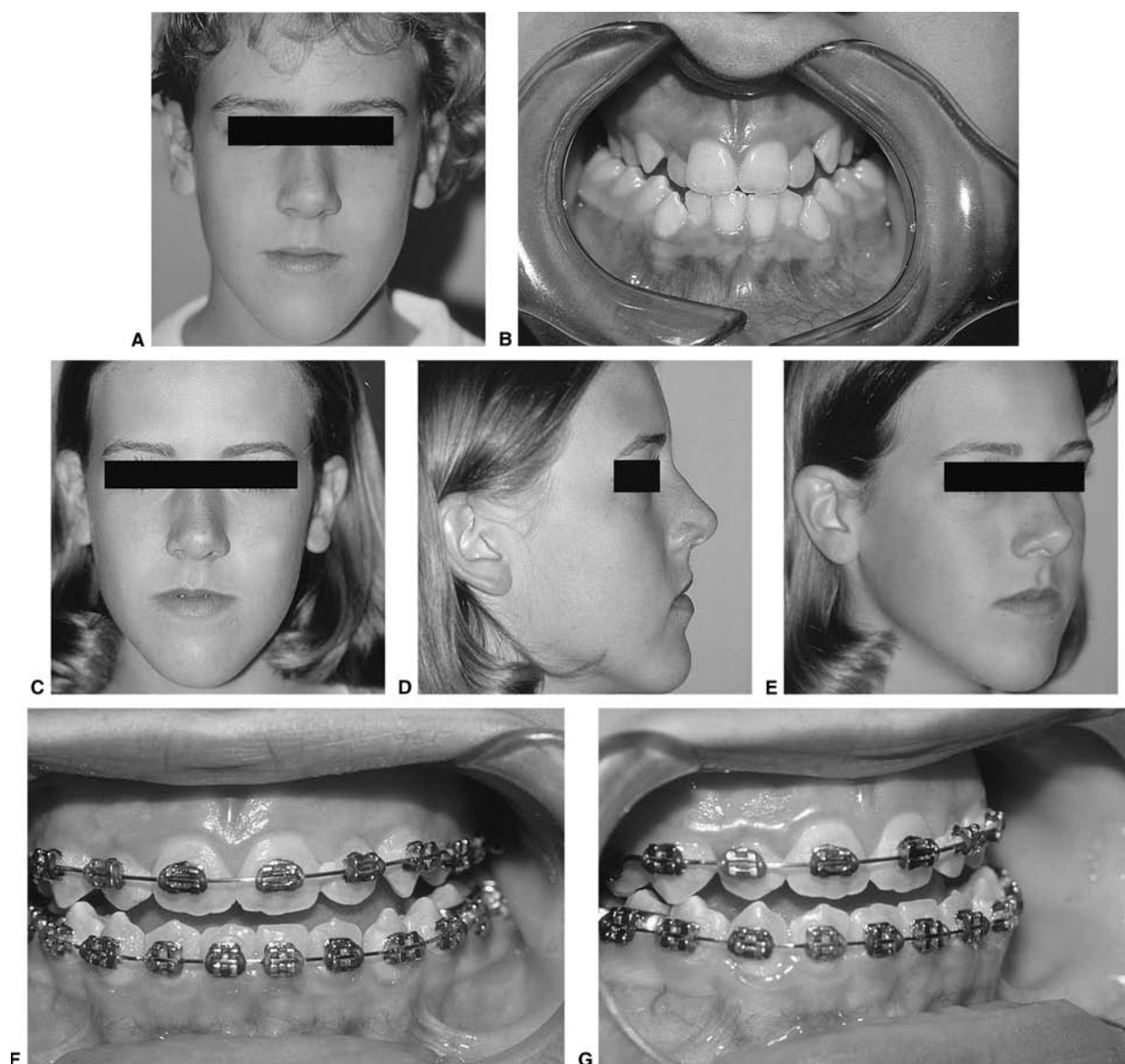


FIGURE 1-84 (A,B) Full face and occlusal views of a 15-year-old girl with class III malocclusion, bilateral crossbite, maxillary hypoplasia, and mandibular prognathism. (C–G) The same patient after orthodontic and prior to two-jaw orthognathic surgery. The dental arches have been straightened, but the class III malocclusion has been accentuated (*continued on next page*).



FIGURE I-84 (continued) (H–L) Six months after two-jaw orthognathic surgery including LeFort I maxillary osteotomy, bilateral sagittal-split ramus osteotomy of the mandible with set back and rotation. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

based. There are many reasons for this condition, and it may be associated with many syndromes (e.g., Nager or Treacher Collins).

Many procedures have been developed for treatment of retrognathism. The sagittal-split osteotomy is the most commonly used technique for correction of mandibular deficiency.¹⁶⁴ This procedure allows for correction of significant bony retrognathism; in addition, correction of the soft tissue pogonion generally follows the bony alteration at a 1:1 ratio.

The technique for sagittal-split osteotomy has been well described. A gingivobuccal-sulcus incision is made from the pterygomandibular raphe to the second molar tooth. Subperiosteal dissection is accomplished on both the lateral and medial surfaces of the mandible. Care is again taken to avoid entering the buccal fat pad. The channel retractor is placed along the medial aspect of the ramus to expose the bone above the lingula.

A horizontal bony incision is made with the Lindemann side-cutting burr through the medial cortex of the ramus. This bony cut is made superior to the mandibular foramen, with care taken to protect the inferior alveolar neurovascular bundle. The vertical lateral osteotomy is performed at an oblique angle in the region of the second or third molar. The two osteotomies

are joined on the anterosuperior margin with a reciprocating saw.

A thin osteotome is used to complete the sagittal split. The osteotome should angle toward the buccal cortex of the mandible, hugging the medial surface of the lateral bony table. This helps avoid injury to the inferior alveolar nerve. A similar procedure is performed on the contralateral side. The distal segment is then positioned with the condyles of the proximal segments held in the glenoid fossae. An acrylic wafer splint is again used to position the dental arches, and intermaxillary fixation is performed. If internal rigid skeletal fixation is used, maxillomandibular fixation is often not necessary.

Temporary or permanent injury to the inferior alveolar nerve is a recognized complication of sagittal-split osteotomy. Permanent lower-lip anesthesia has been reported in 2 to 45% of cases.¹⁶⁵ Relapse of some or all of the mandibular retrusion is also a known complication. Relapse is usually secondary to pull of the suprahyoid musculature. It may also result from improper positioning of the condylar head in the glenoid fossa at the time of mandibular advancement.

Some patients may have normal occlusion before surgery, but a suboptimal aesthetic relationship between the chin and the remainder of the face. This can be determined by dropping a vertical line from the

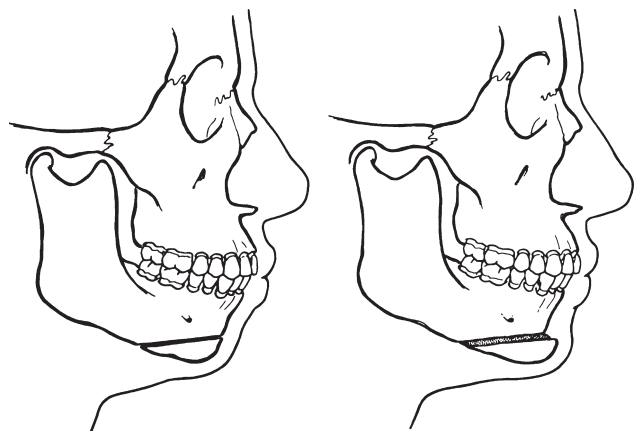


FIGURE 1-85 Schematic diagram of a sliding genioplasty. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

mucocutaneous (vermilion) border of the lower lip. The soft tissue pogonion should almost reach this vertical line in men and is located just posterior to the vertical line in women. If the soft tissue pogonion falls significantly behind this line, microgenia may be diagnosed. In patients with mandibular retrusion and a normal occlusal relationship, osseous genioplasty or chin augmentation may be performed to improve facial harmony. The decision to perform genioplasty versus placement of an alloplast chin implant has been the subject of significant controversy. The choice should be made by the patient based on the surgeon's comfort with each procedure and the patient's specific deformity.

Horizontal sliding genioplasty has the advantage of achieving excellent aesthetic results without the potential risks of an alloplast. Bony genioplasty is performed through an intraoral gingivobuccal incision extending

from one bicuspid to the other. A horizontal incision is made below the tooth roots and subperiosteal elevation is accomplished. The mental nerves and inferior mandibular border are not usually exposed. A horizontal incision is outlined anterior to the emergence of the mental nerves. The horizontal incision is made with a series of burr holes, and these are connected with a sagittal saw or osteotome. The distal segment may then be repositioned anteriorly (Fig. 1-85).

The amount of anterior chin advancement is limited by the need to maintain good bony contact between the proximal mandible and the advanced distal segment. In cases where vertical chin deficiency exists, an interpositional graft may facilitate vertical lengthening (Fig. 1-86). Stabilization of bony segments may be accomplished with interosseous wiring or with lag-screw rigid fixation. Bell et al¹⁵² demonstrated a 0.8:1 ratio of soft tissue response to skeletal change after sliding genioplasty (Fig. 1-87).

MAXILLARY RETRUSION

Facial imbalance may also result when the middle third of the face is positioned suboptimally. The maxilla may be maldeveloped or malpositioned. It may be normal in architecture, but malpositioned anteriorly or posteriorly (maxillary retrusion). Maxillary retrusion may also be associated with maxillary hypoplasia. Maxillary retrusion may be associated with either normal occlusion or class III malocclusion. It may also be present with a normal mandible or simultaneous mandibular malposition.

Diagnosis of midface retrusion may be difficult when the occlusion is normal or when there is simultaneous mandibular deformity. Cephalometric radiography is essential for diagnosis. An SNA angle of less than 79 degrees with a normal SNB angle establishes the diagnosis of maxillary retrusion. It is important to

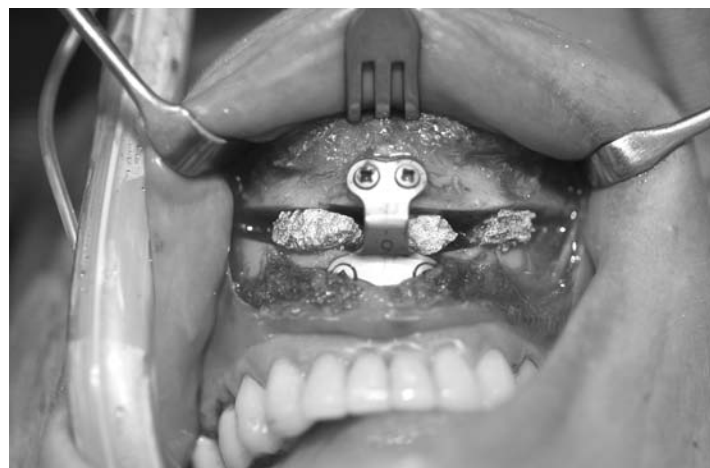


FIGURE 1-86 Photograph of sliding genioplasty with titanium plate and interpositional grafting. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)



FIGURE 1-87 (A) Preoperative lateral photograph of a patient with mild class II malocclusion, retrognathia, and moderate to severe microgenia. (B) Postoperative lateral photograph of the patient after sliding genioplasty and anterior chin advancement. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

analyze not only the position of the skeleton, but also its particular contour in patients with suspected maxillary retrusion. The maxillary deformity may be present inferiorly only, with abnormal angulation of the maxillary alveolar shelves. The entire maxilla may be hypoplastic or retruded, requiring attention to both the inferior and superior aspects of the maxilla.

When maxillary hypoplasia exists and occlusion is normal, onlay grafting is appropriate. Augmentation may be performed with autologous cranial or iliac bone, or may be achieved with alloplast implants. Maxillary and premaxillary augmentation is a useful adjunct to other surgery for dentofacial deformities.

In patients with retrusion of the inferior aspect of the maxilla, a standard Le Fort I osteotomy is indicated (Fig. 1-88). This involves a horizontal cut through the walls of the maxillary sinuses and the nasal septum, coupled with separation of the maxilla from the pterygoid plates. A gingivolabial-sulcus incision is made from the level of one second maxillary molar tooth to the opposite second molar. Periosteal elevation over the anterior nasal spine, pyriform aperture, and face of the maxilla is then accomplished. A decision must be made regarding the exact level at which to make the horizontal Le Fort I osteotomy. The osteotomy is started in the lateral wall of the pyriform aperture. The medial and lateral walls of the maxillary sinuses are cut, with the lateral cuts extending to the pterygomaxillary fissure. A curved osteotome is positioned in the pterygomaxillary fissure inferiorly and driven medially to separate the alveolar segment from

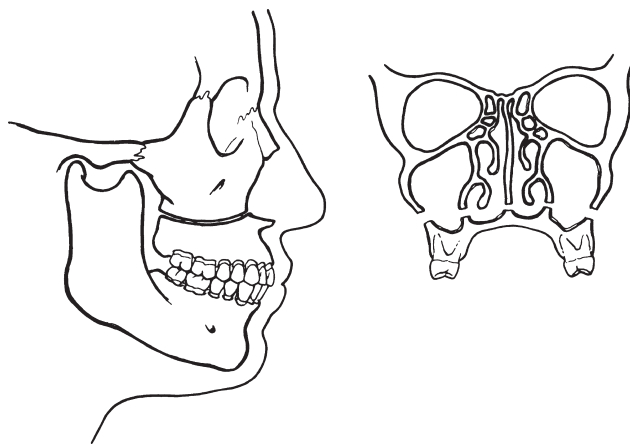


FIGURE 1-88 Schematic diagram of a standard Le Fort I osteotomy of the maxilla. (From Papell ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

the skull base. The maxilla is then down-fractured and mobilized.

Advancement of the maxilla into the predetermined position is then accomplished. An acrylic, occlusal wafer splint is used, and the maxilla is wired to the mandible. The mandibular-maxillary complex may then be moved as a single unit. It is crucial to ensure that the mandibular condyles are well seated in the glenoid fossa before fixation of the maxilla. The maxillary segment may then be stabilized using miniplate rigid fixation. Miniplates should be applied at the thickest portion of the maxilla at the pyriform aperture and zygomatic buttresses. An alternative method of fixation is to use intermaxillary wires, with the acrylic occlusal splint as a guide. Controversy exists regarding posterior stabilization of the maxillary segments with bone grafts to prevent relapse of the retrusion. Some surgeons believe that bone grafts help maintain the alveolar segment in their advanced position.

VERTICAL MAXILLARY DYSPLASIA

The vertical maxillary component in the analysis and treatment of dentofacial deformities has become more important during the past 20 years.¹⁶⁶ *Vertical maxillary excess* is characterized by a short upper lip and excessive incisor show at rest. An anterior open bite may be present. *Vertical maxillary deficiency* is characterized by an apparent excess of upper-lip length, with a lack of incisor display at rest. The ideal lip position at rest shows ~2 to 3 mm of upper incisor. In both forms of vertical maxillary dysplasia, this relationship is disturbed.

Treatment of vertical maxillary dysplasias is usually accomplished using Le Fort I osteotomies. When the

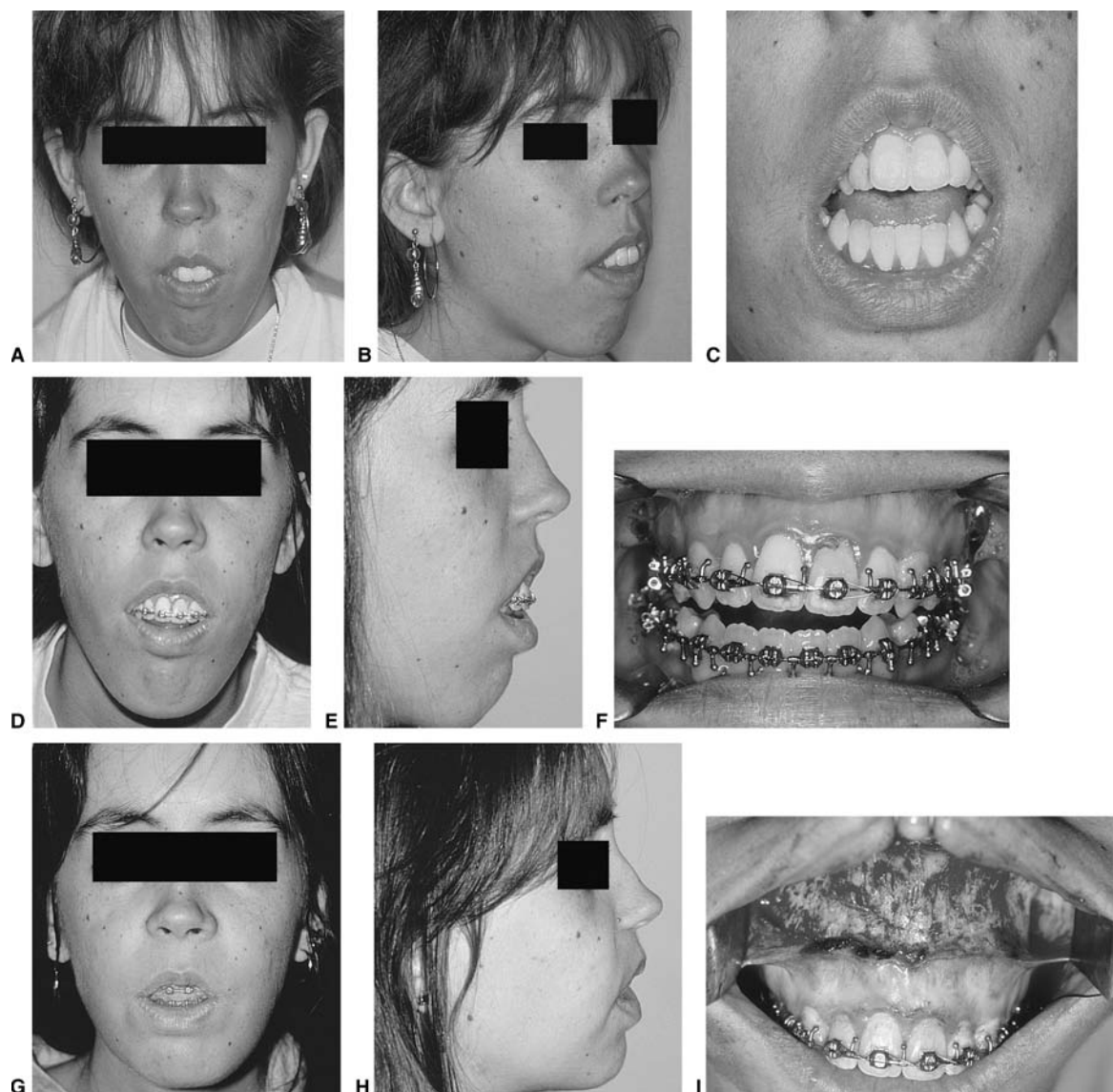


FIGURE 1-89 (A–C) Preorthodontic photographs of an 18-year-old woman with myotonic dystrophy, severe vertical maxillary excess, and premature posterior contact of the occlusion. The patient has a severe open-bite deformity and labial incompetence. (D–F) The same patient after preoperative orthodontic therapy in preparation for Le Fort I maxillary osteotomy with impaction. (G,H) Frontal and lateral photographs of the same patient after Le Fort I maxillary osteotomy with impaction and genioplasty with shortening of the chin. (I) Intraoperative view of the maxilla showing a severely excessive maxilla in vertical dimension. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

vertical dimension of the maxilla is excessive, superior positioning of the maxilla (maxillary intrusion) is accomplished. Bone may then be removed from the lateral aspect of the pyriform rim to accommodate maxillary intrusion (Fig. 1-89). Treatment of maxillary deficiency (short-face syndrome) is accomplished by down-fracture of the maxilla and placement of interpositional bone grafts. In both instances, adequate bone contact must be maintained after osteotomy to ensure good bony healing.

TRANSVERSE MAXILLARY DEFICIENCY

Maxillary constriction was first described by Koler¹⁶⁷ in 1959. The maxillary corticotomy, in which the cortex alone is cut, aids in expansion of the palate. After corticotomy, the contour of the maxilla may be changed by using a palatal expander with a jackscrew appliance (Fig. 1-90). Surgically assisted rapid expansion is an alternative to segmental (multiple-piece) Le Fort osteotomies for correction of transverse maxillary deficiency.

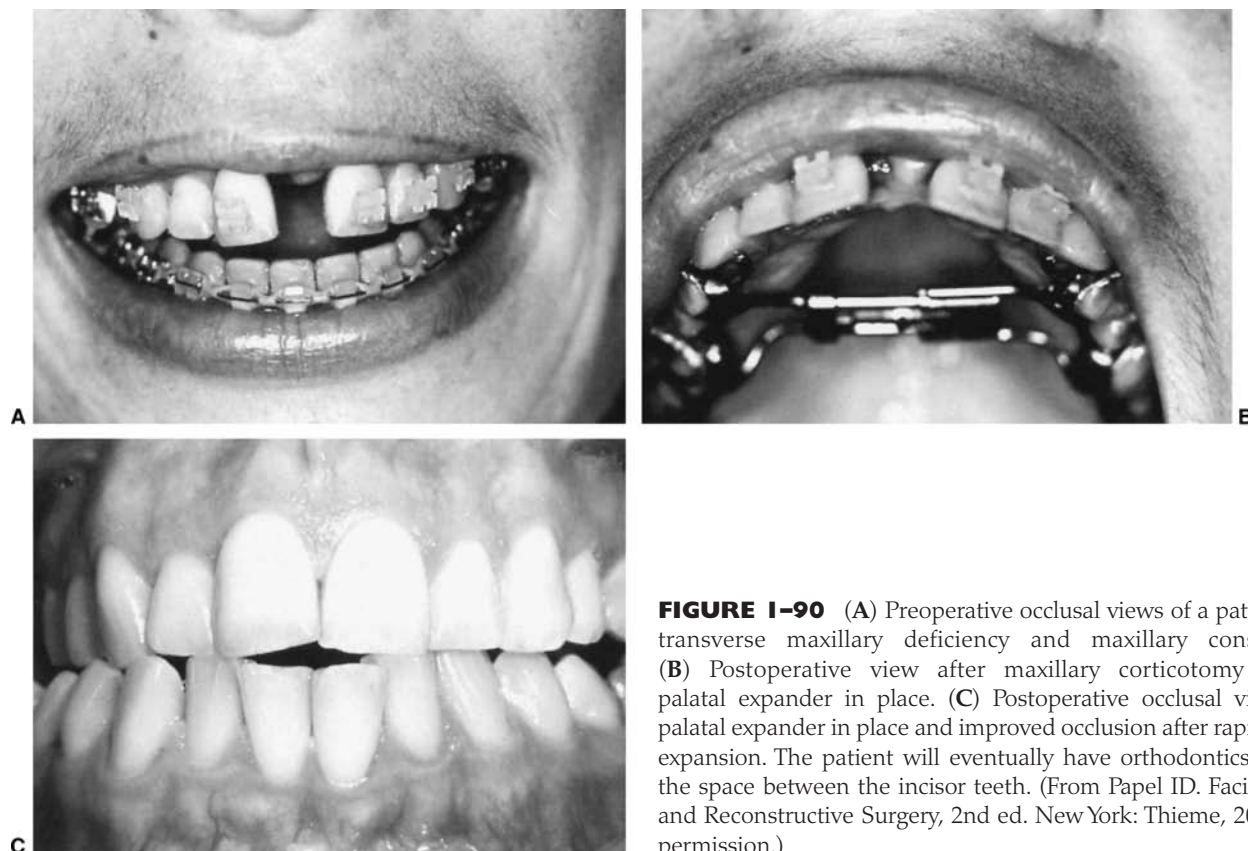


FIGURE I-90 (A) Preoperative occlusal views of a patient with transverse maxillary deficiency and maxillary constriction. (B) Postoperative view after maxillary corticotomy with a palatal expander in place. (C) Postoperative occlusal view with palatal expander in place and improved occlusion after rapid palatal expansion. The patient will eventually have orthodontics to close the space between the incisor teeth. (From Papel ID. *Facial Plastic and Reconstructive Surgery*, 2nd ed. New York: Thieme, 2002, with permission.)

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CUTANEOUS LESIONS AND FACIAL RECONSTRUCTION

Stephen S. Park

Cutaneous lesions of the face and neck are ubiquitous in the elderly group and the accurate diagnosis and distinction among those that are benign, premalignant, and malignant remains critical. This chapter reviews the essential features that aid in this evaluation and presents guidelines for their management. The repair of facial cutaneous defects is an intriguing component of facial plastic and reconstructive surgery; a variety of locations and sizes, as well as functional considerations, call for a wide array of surgical techniques that allows one to achieve the optimal outcome. It is often helpful to have a series of essential principles and a practical algorithm for analyzing some of the more challenging defects. This chapter covers the basic techniques for many common local and regional flaps and discusses the special considerations and nuances of each facial unit. This chapter is not a comprehensive surgical atlas but rather an overview of the essential principles.

CUTANEOUS ANATOMY OF THE FACE

The *epidermis* is the most superficial layer of cells and functions to protect the deeper tissues and retain moisture. Its capacity to do this is seen clinically when patients suffering from thermal burns are overcome by infection and fluid loss. This layer of skin is divided into, from the deepest layer to the superficial one, the stratum basale, stratum spinosum, stratum granulosum, and stratum corneum. The keratinocytes from the basal layer migrate superficially up to the stratum corneum with an average turnover time of ~30 days. Malignant transformation of this cell type is responsible for the de novo birth of a cutaneous squamous cell carcinoma (SCCA), the second most common skin cancer after basal cell carcinoma (BCCA). Melanocytes are found in the basal layer of the epidermis and are of neural crest origin. Their production of melanin gives skin its pigmented color and is thought to protect the keratinocytes from the harmful effects of ultraviolet radiation. The numbers of melanocytes do not vary in people of different races; an individual's skin color is influenced by

the relative production of melanin. Albinism is associated with a congenital deficiency of tyrosinase, an essential enzyme for the production of melanin, and it is characterized by pale skin and a great risk for burning and actinic injury. Langerhans' cells are also within the epidermis and have an important role in the antigenic processing of immunologic responses to the external environment.

Beneath the basement membrane, the *dermis* is divided into the superficial papillary and deeper reticular layers. The dermis contains many essential elements of skin, i.e., fibroblasts, collagen fibers, elastin fibers, ground substance, the neurovascular bundles of skin, the pilosebaceous units (hair follicle and sebaceous gland), arrector pili muscles, eccrine sweat glands, and, in some areas, the apocrine glands (Fig. 2-1). This layer of skin is responsible for many of the external features of skin, such as tone, elasticity, mechanical strength, and wrinkles. Youthful skin is characterized histologically by a well-organized architecture of collagen bundles immediately beneath the basement membrane. These collagen bundles diminish and become more disorganized with time and give rise to the intrinsic wrinkles seen in older individuals. Collagenase is produced by the keratinocyte and accelerates this degradation process. Smoking and actinic injury are thought to increase the production of collagenase, whereas topical tretinoin may inhibit collagenase activity and preserve a more youthful skin tone.¹ The *pilosebaceous unit* consists of the hair bulb, hair follicle, sebaceous gland, arrector pili muscle, and sensory end organs. This important structure produces sebum, retains moisture, regulates temperature, and can stimulate epidermal regeneration. Beneath the dermis, the *subcutaneous fat* envelops the head and neck and is a distinct layer of variable thickness. The eyelids and skin of the external auditory canal are unique in that they contain little or no subcutaneous fat.

The vasculature of facial skin is robust with distinct patterns of perfusion. Within the dermis, there are two vascular arcades, a superficial one between the reticular and papillary dermis and a deeper one often referred to as the "subdermal plexus," the latter usually being dominant. In

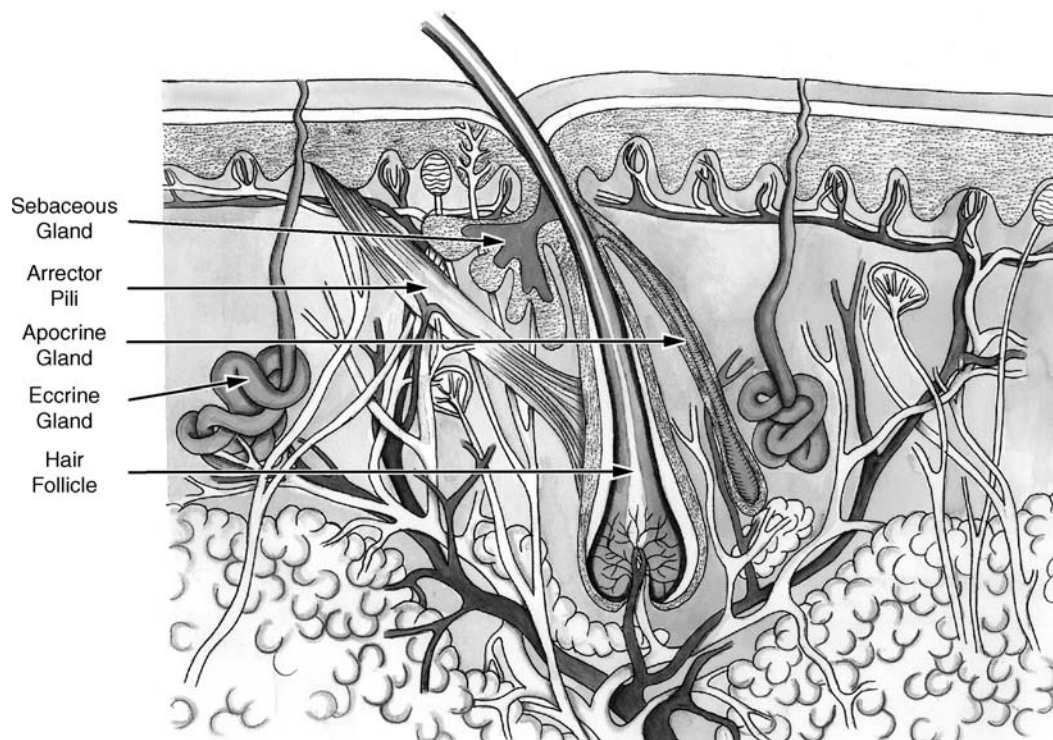


FIGURE 2-1 Skin dermis and hair follicle.

some areas, the vascular supply to the skin is directly from a major perforating vessel off a deeper artery in the muscular or fascial plane (Fig. 2-2). A musculocutaneous vessel perforates the underlying muscle, vascularizing the muscle en route to the skin. The direct cutaneous arteries also arise from the deeper larger vessel but travel within fascial slips between muscles to nourish the skin exclusively. Flaps can be defined by their vascular supply, as discussed below.

CUTANEOUS LESIONS

EPIDEMIOLOGY

Cutaneous malignancies are by far the most common malignancy in humans and fortunately are associated with a favorable prognosis. Eighty percent of these lesions are found on the face and neck, the nose in particular (30%), and the nasal tip subunit specifically.² The forehead and cheeks are also areas of particular risk. There are over a half million new cases in the United States annually, with a lifetime risk of ~33% in Caucasian Americans.²⁻⁴ Among individuals with a history of a skin cancer, the risk of a second neoplasm increases dramatically to roughly 50% within 5 years and speaks to the need for diligent follow-up.^{5,6}

RISK FACTORS FOR SKIN LESIONS

Exposure to the sun and harsh environment is by far the greatest risk for the development of cutaneous malignancies; thus outdoor occupations and living closer

to the equator or at higher altitudes are demographic risk factors. Ultraviolet (UV) rays are defined by their wavelength and categorized as UVA, UVB, or UVC. UVA rays are primarily responsible for melanocytic stimulation and tanning. UVB rays (290–320 nm) cause the greatest DNA injury and are most responsible for the neoplastic degeneration of epidermal cells (“B” for “bad”). Radiation from the UVC spectrum is mostly absorbed by the ozone stratosphere and has little impact on skin injury. Short bursts of intense sun at an early age appear to be more damaging than long-term, low-dose exposure; a child with recurrent sunburns may be at greatest risk for future skin malignancies.

In addition to the volume of sun exposure, several other variables are associated with an increased risk for cutaneous malignancies. Genetic and ethnic influences can predispose individuals to skin lesions, particularly individuals from Northern European or of Celtic origin (Fitzpatrick skin types I and II). *Basal cell nevus syndrome* is a genetic syndrome afflicting younger people and is characterized by multiple BCCAs reoccurring throughout the body.⁷ It is also associated with bifid ribs, frontal bossing, and mandibular cysts. *Dysplastic nevus syndrome* is a familial disease where a large number of irregular nevi continue to form throughout life and is associated with a risk of malignant melanoma. Very close observation with serial photographic documentation is imperative for prompt diagnosis and treatment of this malignant disease. *Xeroderma pigmentosa* is an autosomal-recessive disorder associated with improper DNA repair leading to extreme actinic sensitivity and multiple cutaneous

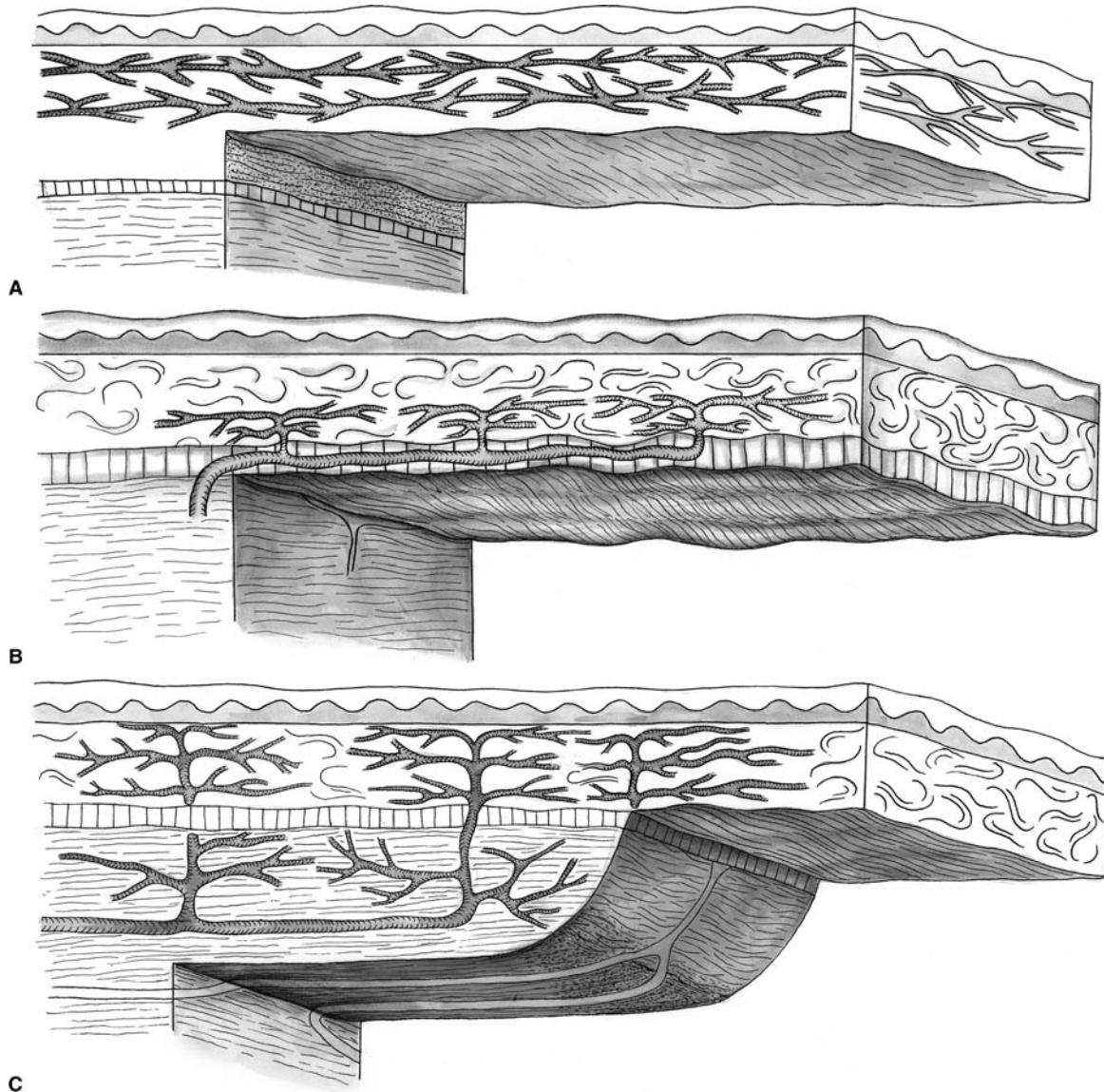


FIGURE 2-2 Blood supply to the skin. (A) Subdermal plexus used in random donor flaps. (B) Fascial cutaneous pattern using a single, axial vessel within the fascial plane over the muscle. (C) Musculocutaneous pattern is based on perforators from deep muscular arteries.

malignancies. *Bowen's disease* is characterized by diffuse areas of erythematous and scaly plaques that show full-thickness epithelial dysplasia or SCCA in situ. Although the disease is superficial and does not violate the basement membrane, the involved regions warrant close monitoring and conservative treatment due to the risk of malignant degeneration.

Low-dose *ionizing radiation* was a common practice years ago for the management of acne or adenotonsillar hypertrophy. Long-term effects of this superficial radiation have been implicated for carcinogenesis. *Immunosuppression* from a systemic illness, be it neoplasm, human immunodeficiency virus (HIV), or allograft transplantation, is also associated with an increased risk of multiple cutaneous malignancies.⁸ Areas subject to chronic inflammation such as infected

sinus tracts, nonhealing ulcers, and old scars from burns show a predilection for neoplastic degeneration.^{7,9} Prolonged exposure to chemicals such as arsenic and hydrocarbons also appears to be a risk factor for cutaneous malignancies.^{6,10}

BIOPSY TECHNIQUES

The diagnosis of a cutaneous lesion is occasionally obvious from clinical inspection alone, but at other times it remains elusive, even to the trained eye. In general, lesions tend to be representative of their cell of origin. Tumors arising from the epidermal layer present as superficial growths that are often scaling. Deeper lesions, on the other hand, tend to push up the epidermal layer and present as more nodular growths with normal-appearing

surfaces. Clinical presentations have a tremendous overlap, and the definitive diagnosis comes with biopsy and histologic examination, at times with special stains. There are several different biopsy techniques available but they share a common goal of obtaining sufficient tissue for diagnosis while minimizing morbidity, patient discomfort, and subsequent inflammation that might hinder the examination of specimen margins.

Shave biopsy is one of the most common and effective techniques and has two distinct advantages: (1) the biopsy site heals rapidly with local wound care alone, and (2) the deeper tissues are left undisturbed without inciting an inflammatory host reaction. The latter issue becomes important when definitive excision is being performed. Surrounding host inflammation is often suggestive of adjacent tumor invasion and can be misleading when this is found along the deep margin of the specimen. The biopsy itself incites some surrounding inflammation. The shave biopsy should be performed to the mid-dermis level to make an accurate diagnosis (Fig. 2–3). It should not be performed, however, on a pigmented lesion where a malignant melanoma is possible because the depth of invasion is paramount in defining treatment and prognosis. A *punch biopsy* is equally rapid and dependable, giving a sufficient amount of tissue for analysis of tumor depth. The wound can be closed with a single stitch and heals well. Disposable punch instruments vary in size and a 2- to 4-mm diameter is adequate. By applying traction to the skin perpendicular to the skin tension lines prior to the punch excision, the resultant defect assumes an elliptical shape and assists with closure along those lines. *Incisional biopsy* is utilized for larger tumors or in anatomically sensitive areas such as around the eyes or nose. It is best to sample the margin of the lesion, capturing a small amount of surrounding normal skin and avoiding areas of central necrosis. For pigmented lesions, it is imperative to biopsy full-thickness skin, into subcutaneous tissue, to determine lesion depth. *Excisional biopsy* is useful when the clinical suspicion is low and the lesion is small enough to permit a single-stage treatment.



FIGURE 2–3 Shave biopsy of a cutaneous lesion. Biopsy is taken down to the reticular dermis.

TREATMENT OPTIONS

While selecting the definitive treatment, it is important to bear in mind that a disproportion of *recurrent* lesions (90%) occur on the face and neck rather than other regions of the body.¹¹ One implication of this is that primary malignancies of the face are being inadequately treated initially, perhaps due to aesthetic concerns. Furthermore, recognizing that recurrent lesions are often more aggressive and difficult to control, every effort should be made to ensure complete eradication initially, especially during direct excision and primary repair.

Application of topical 5-fluorouracil (Effudex, ICN Pharmaceuticals, Inc., Costa Mesa, CA) blocks DNA synthesis in dividing cells and is an effective means of treating scattered lesions, especially multiple, premalignant actinic keratoses. Moderate erythema and desquamation are expected for several days following treatment. Chemical penetration is minimal beyond the epidermis and thus not indicated for deeper lesions. Deep chemical peels, dermabrasion, and laser resurfacing are other methods of resurfacing that are occasionally used for diffuse and superficial skin lesions.

Isolated premalignant lesions and well-defined superficial cancers can be managed conservatively with *cryotherapy*. This technique freezes the lesion through application of a cryogen such as liquid nitrogen, which drops the skin temperature to -50°C . As intracellular ice crystals form and later thaw, local tissue destruction occurs and tumor cell death results. This cycle can be repeated for additional tissue destruction. The treated area develops some erythema, exudate, and occasionally a small bulla, but the final cosmetic outcome is generally excellent. When used appropriately, the cure rates for this technique approach 95% and have the advantage of being simple, safe, and inexpensive.^{12,13}

Curettage and desiccation (C&D) may be the most widely practiced method of treatment for skin cancers.¹⁴ Like cryotherapy, it is indicated for smaller, well-defined, nonmelanoma skin cancers and is characterized as being simple and inexpensive and having acceptable cure rates.^{2,7} The technique involved a vigorous scraping of the lesion with a hand-held curette followed by electrodesiccation of the wound base. The process can be repeated for two to three cycles. The resultant defect is allowed to heal by second-intention. There are two disadvantages to C&D: (1) there is no specimen from the procedure for analysis, and (2) the defect is usually a small crater that leaves a contour irregularity and patch of hypopigmented scar.

More complex cutaneous lesions are usually treated definitively with direct *surgical excision*. When the diagnosis is suspected and the lesion relatively small, one can plan an excisional biopsy with close margins. Clinical margin for surgical excision of a known BCCA should be

TABLE 2-1 MINIMUM SURGICAL MARGINS FOR DEFINITIVE EXCISION

<i>Type of Cancer</i>	<i>Margin (mm)</i>
Nodular BCCA	2–3
Morpheaform BCCA	4–5
SCCA	4–5
Lentigo maligna (melanoma in situ)	5
Malignant melanoma	10–15

BCCA, basal cell carcinoma; SCCA, squamous cell carcinoma.

about 2 to 3 mm, 4 to 5 mm for a SCCA, and 10 mm for a melanoma (Table 2-1). Standard excision has the advantages of being relatively direct, providing a permanent specimen, leaving a favorable cosmetic repair, and having cure rates that approach 95%.^{2,15} It is essential to bear in mind, however, that traditional pathologic sectioning reviews less than 2% of the surface area of the specimen margin, allowing nests of tumor to penetrate and remain undetected. When the clinical margin is more ambiguous, even frozen section control does not adequately assess tumor margin and the risk of recurrence rises dramatically.¹⁵ When a positive specimen margin is identified, the risk for recurrence is roughly 33% and reexcision is indicated.^{16,17} It is interesting to note that the recurrence is not 100%, implying the ability for a host to successfully combat the remaining tumor cells. Alternatively, one is forced to take a larger margin from an area where maximal tissue preservation may be imperative. The importance of proper selection of lesions to be treated with simple excision cannot be overemphasized.

Mohs' micrographic surgery was first described by Frederic E. Mohs while he was a medical student at the University of Minnesota in the early 1940s. Although some of the technical aspects have changed, the principles have revolutionized the contemporary management of skin cancers and have defined the gold standard for treatment, reaching cure rates of 99%. Even challenging tumors such as poorly defined SCCAs or infiltrating BCCAs can be cured in ~95% of cases, in contrast to 75 to 90% by other techniques.^{18,19} Mohs' surgery requires careful mapping of the entire margin of a cutaneous lesion, including the deep surface, followed by frozen-section analysis. Based on these histologic readings, the lesion is serially excised to ensure complete extirpation of tumor while maximizing preservation of uninvolved skin. Indications for Mohs' surgery are influenced by physicians' preferences, but general considerations include recurrent malignancies, lesions in fusion planes where subclinical extension is likely, lesions arising in areas where tissue preservation is critical, such as the eyelid or nose, ill-defined lesions such as most SCCAs and some BCCAs (*infiltrating*, *morpheaform*, or *keratotic*), large tumors (>2 cm on the face), or tumors arising within

TABLE 2-2 INDICATIONS FOR MOHS' SURGERY

Limited surrounding skin
Ill-defined borders
Recurrent tumor
Tumors within scars or irradiated tissues
Aggressive BCCA subtype
Morpheaform
Sclerosing
Infiltrating
Micronodular
SCCA, poorly differentiated
Perineural invasion

scars or irradiated skin (Table 2-2). Melanomas are not efficiently managed by Mohs' surgery because malignant melanocytes are difficult to detect by frozen-section methods and skip lesions occur frequently and would remain undetected. For this reason, larger margins are used during definitive excision for pigmented cutaneous malignancies (discussed below).

Radiation therapy has been used for many decades as a treatment modality for cutaneous malignancies, but its use declined recently due to the advances in surgical techniques, both for excision and reconstruction. Nevertheless, it remains an effective and noninvasive means of treatment with cure rates for primary neoplasms approaching 90%.^{7,20} The most frequent clinical scenarios in which external radiation is selected include positive margins, perineural invasion, palliative treatment, and poor surgical candidates. Cure rates for primary lesions correlate directly with tumor size; lesions greater than 2 cm have a poorer control rate and are seldom used primarily. Disadvantages of radiation include treatment duration (4–6 weeks), local skin irritation, erythema, atrophy, hair loss, telangiectasia, and hypopigmentation, some of which can be cosmetically problematic. Repeated courses of treatment are rarely tolerated and, because multiple and recurrent lesions in this patient group are the rule rather than the exception, one must recognize that potential future modalities are being exhausted.

There are other less conventional treatment modalities that are currently being investigated. *Photodynamic therapy* (PDT) involves the topical application of a chemical (aminolevulinic acid), which is then absorbed and metabolized by the tumor cells into a photosensitizing porphyrin. The lesion is then exposed to high-energy light and the photoporphyrins generate a cell toxin and lead to tumor death.²¹ PDT appears successful for superficial skin lesions with cure rates around 90%; however, larger, more aggressive tumors do not respond as well. Intralesional injection of *interferon-α* may have a tumoricidal effect by promoting the cytotoxicity of natural T cells.^{22–24} Host immune response may have an important role in tumor surveillance. Retinoids are a derivative of vitamin A that influences cell growth and their beneficial

effects on actinic keratoses have been shown.²⁵ Systemic, high-dose *retinoids* have a beneficial effect in terms of controlling skin tumors in immunosuppressed patients as well as those with xeroderma pigmentosum and basal cell nevus syndrome.^{26,27} Its role in the prevention of cutaneous malignancies among people at high risk remains to be defined.

Nonpigmented Benign Neoplasms

Warts

Verruca vulgaris, the common wart, is a common epidermal neoplasm caused by the human papilloma virus (HPV) and usually presents as a small (1–2 mm) nodule or occasionally a flat (*verruca plana*) or filiform lesion with a narrow pedicle. It usually occurs in children and can be self-limited. Histologically, there are benign, hyperkeratotic epithelial cells. *Molluscum contagiosum* is a variant related to the pox viral family and appears as multiple, small, waxy, dome-shaped lesions scattered over a facial unit. The treatment for warts is usually sharp excision or cryotherapy but recurrence is the rule with inadequate management, especially at the base of the lesion. Curettage or laser ablation are alternative methods that can be successful. Fortunately, most viral lesions are self-limited, and they involute from the host's immune response.

Seborrheic Keratoses

Seborrheic keratoses are benign skin lesions that are common in adults, especially in those with a history of sun exposure. The lesions are typically brown, well demarcated, soft to touch, and slightly raised. On occasion they are verrucous and have a keratotic plug. The color tends to be uniform but there can be enough variability to resemble a melanotic growth. Histologically, the neoplasm is limited to a superficial hyperkeratosis and acanthosis without deep extension. Because there is no malignant potential, no intervention is mandatory; however, excellent cosmetic treatment can be accomplished with sharp excision using a shave technique, cutting the lesion flush with the surrounding epidermal layer. Cryotherapy is an effective alternative. Although the lesions themselves are benign, a “shower” of seborrheic keratosis may suggest internal malignancies, particularly adenocarcinoma of the colon (Leser-Trelat sign).

Actinic Keratoses

Actinic keratoses are premalignant lesions commonly found on all sun-exposed areas of skin, especially in the elderly. They typically appear as small, scaly, and flat lesions with irregular borders and an erythematous base. Patients often feel the rough lesion before a visible, demarcated growth is seen. Most lesions occur at multiple sites and are more common in people with fair skin (Fig. 2–4). Histologically, one finds cellular atypia within the epidermal layer but without clear malignant features.



FIGURE 2–4 Actinic keratoses with multiple, scaly lesions with an erythematous base. (See Color Plate 2–4.)



FIGURE 2–5 Actinic cheilitis. (See Color Plate 2–5.)

When they arise on the lips, especially the lower, they are known as *actinic cheilitis* (Fig. 2–5). The risk of these lesions evolving into a cutaneous malignancy, both SCCA and BCCA, is 10 to 20% over a lifetime.

Actinic keratoses require definitive treatment due to their known malignant risk. Isolated lesions can be addressed with shave excision or cryotherapy. Because they often occur in large numbers, surgical excision may not be practical and diffuse topical treatments are often needed. Topical 5-fluorouracil is effective and frequently applied to large facial units, creating a posttreatment erythema and irritation that patients must be forewarned about.

Keratoacanthoma

Keratoacanthoma (KA) is an epithelial neoplasm usually occurring as a solitary lesion on sun-exposed surfaces of the elderly. These solitary lesions are characterized by rapid

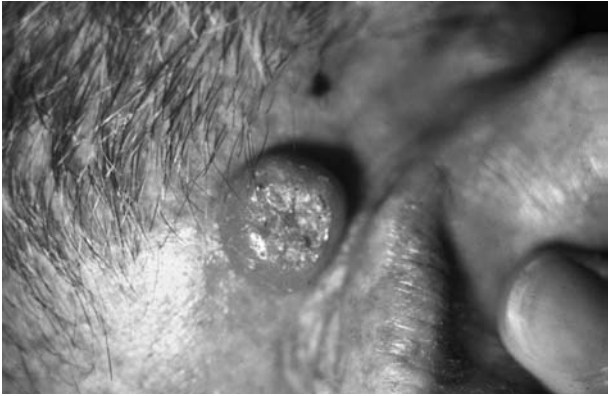


FIGURE 2-6 Keratoacanthoma. Raised nodular lesion with central, keratotic plug. (See Color Plate 2-6.)

growth and were originally assumed to be malignant. Closer inspection, however, has revealed that these lesions are often clinically and histologically distinct from SCCA. Most importantly, they are characterized by three unique clinical phases: rapid growth, plateau, and involution. Typically, the lesions reach full size in 2 months, and they then begin involution by the sixth month. Grossly, they appear as a dome with central keratin plug, usually reaching 1 to 2 cm before stabilizing (Fig. 2-6). Histologically, there are only benign epithelial cells with pushing borders and no violation of the basement membrane.

There are variations from the typical KA. The *giant KA* can reach greater than 5 cm and cause permanent destruction to underlying tissues before involution commences. Multiple lesions can also arise and appear to be a different form of this disease, occurring in younger patients and occasionally on palms and soles.

The treatment of KA is controversial due to the spontaneous involution that characterizes this lesion. Observation until regression is an option but it may take 6 to 8 months, and mandates diagnostic certainty. Unfortunately, there is also a concern for “malignant transformation” of these lesions. It is unclear if they degenerate into a malignancy or if they represented low-grade SCCA from the onset. There are reports of histologically confirmed KAs that have behaved as malignancies, including distant metastases.²⁸ Watchful waiting while a possible SCCA is progressing is not clinically prudent. Therefore, surgical excision is probably the treatment of choice for KA, allowing complete pathologic analysis. Larger lesions of the face are best excised via Mohs’ techniques, although some are managed with intralesional injection of cytotoxic agents, with the goal of expediting involution.

Cysts

Cutaneous cysts of the face and neck are common yet frequently misunderstood in terms of etiology and classification. An *epidermoid inclusion cyst* is a true cyst in the

sense that it is lined with stratified squamous epithelium and filled with keratin debris. Its etiology is unclear but it is postulated to arise from traumatic implantation of normal epithelial cells below the skin surface or de novo growth from deeper pilosebaceous units. When multiple cysts are found in a young child, one should consider *Gardner’s syndrome* in which multiple epidermoid cysts are found in this autosomal-dominant disorder associated with intestinal cancer. Treatment is usually direct excision and should include the entire specimen. *Milia* are similar inclusion cysts but are smaller, whitish lesions found in the superficial epidermal layer and often arise from suture or a skin resurfacing procedure, e.g., dermabrasion. The treatment for milia is either simple unroofing of the cyst, direct excision, or occasionally dermabrasion. *Sebaceous cysts* come from plugged sebaceous glands within the dermal layer. They can enlarge significantly and occasionally become infected or spontaneously rupture. Surgical excision is the optimal treatment. *Dermoid cysts* refer to an embryologic disorder, which occurs from an incomplete resorption of an embryologic tract, leading to entrapped ectodermal tissues and cyst formation. Normal embryologic fusion planes are areas of risk for dermoid cysts. *Mucous cysts* are small, almost translucent cysts found within mucous membranes and are not true cysts in that they are not epithelial lined. They are thought to arise from a disruption of a minor salivary gland duct.

Keloids are an extension of hypertrophic scars where the proliferation of fibroblasts and scar tissue extends beyond the boundaries of the original scar. They can lead to a massive overgrowth and present a tremendous therapeutic challenge (Fig. 2-7). Intralesional steroids, long-term pressure bandages or suits, and partial laser resection are

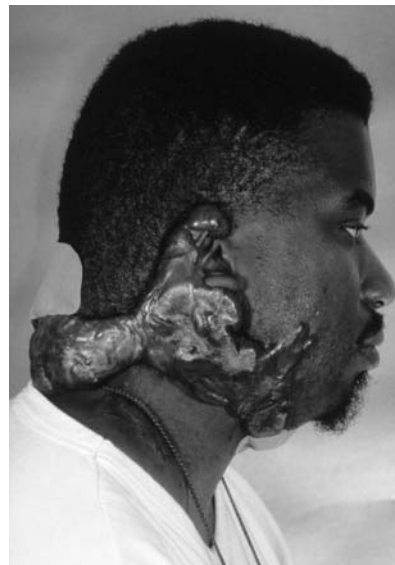


FIGURE 2-7 Keloid. Massive overgrowth of scar tissue.

treatment options with some success. *Dermatofibrosarcoma protuberans* is a locally aggressive tumor of fibroblasts that should be resected with wide surgical margins or via Mohs' techniques to minimize the risk of local recurrence. The infiltrative nature of this tumor often results in a larger cutaneous defect than first expected. *Xanthelasma* are large yellow plaques often found on the lower eyelids of adults and can be associated with elevated triglyceride levels. Treatment involves surgical resection or occasionally topical trichloroacetic acid or cautery. *Syringomas* are also yellow or flesh-colored lesions found on the eyelids of young adults. They tend to be smaller papules arising from eccrine sweat glands. *Trichoepithelioma* are flesh-colored nodules usually found on the eyelids, cheeks, and nose of young women. They may be multiple and can resemble a BCCA, even histologically.

Nonpigmented Malignancies

Basal Cell Carcinoma

Basal cell carcinoma (BCCA) is the most common malignancy found in humans, occurring most often on sun-exposed areas, the face and neck in particular, and are directly associated with chronic exposure to the sun's ultraviolet rays (UVB). The nose is the most common subsite involved, followed by the cheeks and forehead. Cutaneous malignancies are more common in elderly men with fair complexion, those living at higher altitudes or closer to the equator, and in individuals with a history of significant exposure to the sun.

There are subtypes of BCCA (nodular, morpheaform, keratotic, and recurrent) that have distinct clinical and histologic features. *Nodular* BCCA is the most common type and classically presents as a well-circumscribed, nodular growth with a slightly translucent color, superficial telangiectasia, and little surrounding induration (Fig. 2-8). There may be a *pearly border* to the lesion that is characteristic of BCCAs, which becomes more evident when stretching the surrounding skin (Fig. 2-9). Less



FIGURE 2-8 Nodular basal cell carcinoma (BCCA) of the nose. Note the circumscribed border, telangiectasia, and glossy appearance. (See Color Plate 2-8.)

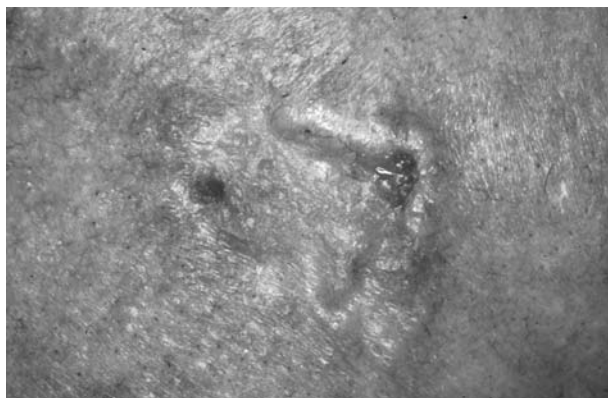


FIGURE 2-9 Basal cell carcinoma with raised, pearly borders. (See Color Plate 2-9.)

often, a BCCA contains areas of ulcerations or pigmentation. Patients often report a benign-appearing, small skin growth that may itch or occasionally bleed but does not resolve spontaneously. Histologically, the cell of origin for a BCCA is from the basal layer of the epidermis, which undergoes cytologic atypia and invades the basement membrane. With lower magnification, there is a collection of circumscribed, small, blue cells arranged in a nodular architecture. One of the pathognomonic signs is *peripheral palisading*, seen as a row of cells along the border of the lesion oriented in a distinct radial fashion (Fig. 2-10).

The other subtypes of BCCA tend to be more difficult to diagnosis clinically, behave more aggressively, and are more challenging to treat. The *morpheaform* BCCA, as its name implies, may be flatter, more yellow in color, and scar-like. The margins are indistinct with subclinical extension and dermal infiltration. There are often fibrotic and

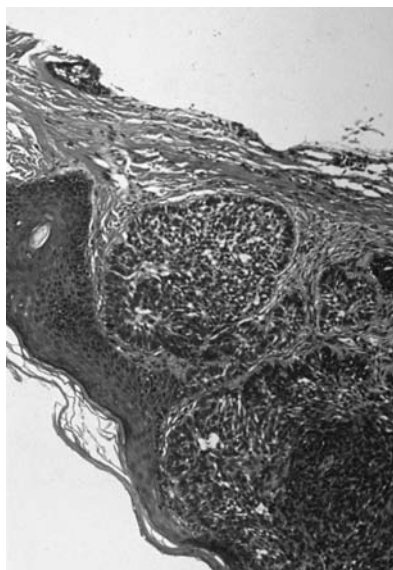


FIGURE 2-10 Histology of a BCCA with nodules of small, dark blue cells and peripheral palisading. (See Color Plate 2-10.)

sclerosing features within the finger-like projections. *Keratotic* BCCA is also more elusive and is characterized by areas of keratin deposits with a field of typical BCCA. For this reason, the lesion is also referred to as a “basosquamous” carcinoma, although monoclonal antibody staining has demonstrated that it is a keratinizing BCCA rather than some intermediate neoplasm between a squamous and basal cell. *Recurrent* BCCA is considered a distinct subtype because of its varied clinical presentation, deviation from the traditional histologic forms, and unpredictable behavior. It readily infiltrates along previous scar planes and makes complete excision more challenging.

PEARL... It is important to subtype all BCCAs, and the morpheiform, sclerosing, and recurrent lesions should be treated more aggressively, and usually via Mohs' excision.

The treatment goal for all BCCAs is complete cure, and direct surgical excision remains one of the most common modalities used. Direct excision with a 2- to 3-mm margin and frozen-section control is generally adequate for classic nodular lesions where the borders are confidently seen. Other methods, such as cryotherapy or curettage and electrodesiccation, can be used for smaller and more superficial lesions and are probably the most widely used treatment. Ill-defined tumors, such as the morpheiform subtype, have finger-like projections that can be easily missed by simpler techniques and warrant Mohs' surgical excision for acceptable cure rates and maximal tissue preservation. When Mohs' surgery is not an option, the clinical margin should extend to at least 4 to 5 mm to capture the subclinical extensions. For smaller tumors in difficult locations, primary radiation therapy is a reasonable alternative and provides adequate cure rates when used selectively. It may also be indicated for those rare occasions when massive tumor growth has occurred and palliation is intended or as adjunctive therapy when there is extreme histologic aggression or evidence of perineural invasion.

There are several investigational and alternative treatments for BCCA. Topical 5-fluorouracil (5-FU) blocks DNA synthesis in rapidly dividing cells and works well for premalignant lesions. Intralesional 5-FU has been effective for smaller BCCAs with cure rates between 80 and 90%.²⁹ Photodynamic therapy with topical aminolevulinic acid as a sensitizer has shown some success as porphyrins and light-activated oxygen free radicals create tumor cell death.²¹ Finally, intralesional interferon- α may act as a cytokine and enhance the local T-cell cytotoxicity against tumor cells. Preliminary studies suggest cure rates of 80%.^{22,23}

Squamous Cell Carcinoma

Squamous cell carcinoma (SCCA) is very similar to BCCA in terms of etiology and risk factors, occurring most often

on sun-exposed areas of fair-complexioned adults with a history of actinic exposure. As a general rule, however, three important distinctions are made: (1) SCCAs tend to have more ill-defined borders, making simple excision less dependable; (2) they grow more rapidly; and (3) they are more likely to be associated with regional metastasis, especially lesions of the lower lip where cervical metastasis may occur in 10% of the cases. Depth of invasion has a greater prognostic impact in these lesions.

PEARL... Squamous cell carcinoma is different from BCCA in that it tends to have ill-defined borders, to grow rapidly, and is more likely to metastasize. It should be treated more aggressively.

The typical clinical presentation of SCCA is similar to an aggressive actinic keratosis with scaling, an erythematous base, and a raised margin. It may also show ulceration, pigmentation, and a nodular form (Fig. 2-11). It has variable growth phases and occasionally takes on an extremely exophytic growth, resembling a keratoacanthoma. Histologically, the lesion is characterized by a deep infiltration of large keratinocytes, lightly staining with hematoxylin and eosin (H&E), and scattered, small, keratin pearls (Fig. 2-12). Different subtypes exist for SCCA: generic, adenoid, bowenoid, verrucous, and spindle. *Bowenoid* is the invasive counterpart to Bowen's disease with infiltration below the basement membrane. *Verrucous* SCCA is more exophytic and verruciform, only invading deeper tissues with blunt, pushing borders. The *spindle* cell type is more aggressive and elusive to diagnose.

Treatment for some select superficial SCCAs and a majority of premalignant cutaneous lesions can be effectively managed nonsurgically with cryotherapy or with an aggressive resurfacing technique. Most confirmed SCCAs are managed with surgical excision utilizing slightly larger margins (at least 4–5 mm) due to the less discrete borders in contrast to those of BCCA. Furthermore, the threshold for Mohs' surgery is lower with SCCAs of



FIGURE 2-11 Squamous cell carcinoma (SCCA) that appears ulcerating, erythematous, has some pigmentation, and has less distinct borders. (See Color Plate 2-11.)

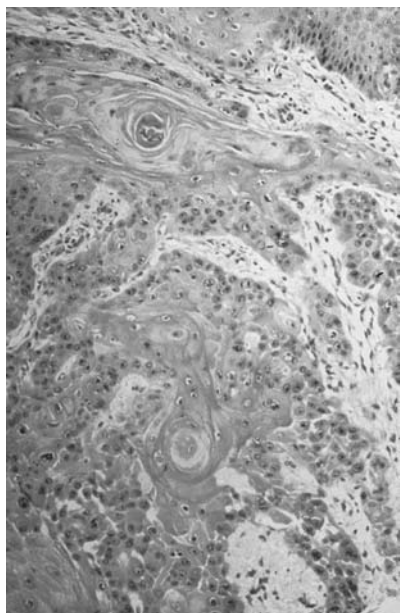


FIGURE 2-12 Histology of a SCCA with nests of large, pink cells and occasional keratin pearls. (See Color Plate 2-12.)

the face. Regional lymphatics are a greater consideration than with BCCAs due to the propensity for metastasis. Histologic evidence of *perineural invasion* portends a graver prognosis, and postoperative adjunctive radiation should be strongly considered. SCCAs arising on the ear and lips also behave in a more aggressive fashion and warrant a thorough investigation for metastatic disease as well as complete primary treatment.

Pigmented Lesions

Nevi

Skin pigmentation comes from the production of melanin by melanocytes in the basal epidermal layer. These cells are of neural crest origin and give rise to a variety of pigmented neoplasms of the skin. Melanocyte-associated tumors are found in the dermal layer rather than epidermis and are the cell of origin for both benign nevi and malignant melanomas. Nevi are classified into several subtypes.

Congenital Nevi

As the name implies, congenital nevi exist at birth and are found in a variety of sizes and locations. Most are relatively small, dark brown in color, and well circumscribed. Histologically, the pathognomonic feature of a congenital nevus is the presence of melanocytes adjacent to the pilosebaceous units. Melanocytes are otherwise present in all layers of the dermis. A subtype of the congenital nevus is the *congenital giant (hairy) nevus* where lesions are greater than 5 cm in diameter and often contain small amounts of hair. These larger lesions are significant for their malignant degenerative potential, especially into a malignant melanoma (10–20%). This risk increases with

age, especially during puberty, and earlier definitive excision is recommended. Massive nevi (>20 cm) become high risk after the age of 1 and are ideally excised shortly after the first year of life. Many lesions require a staged, serial excision due to the elasticity of a child's skin and limited recruitment potential with local flaps. Truncal nevi may not be practical to excise, and close serial observation with frequent biopsies may be the only option.

Junctional Nevi

Junctional nevi develop in young children and are a uniform brownish color, small, well circumscribed, and flat. As their name implies, the melanocytes are found at the dermoepidermal junction, and, because these cells are located more superficial than their adult counterparts, they tend to be darker in color. Although a great majority of all pigmented cutaneous lesions remain benign throughout life, this group has a risk of malignant degeneration, usually occurring after puberty. With time, the melanocytes appear to descend through the skin layers and “evolve” into the typical benign adult nevi. Treatment is dictated by concern for malignancy or cosmesis. When in doubt, a deep biopsy should be obtained. Aesthetic treatment includes direct excision, shave removal, or deep cryotherapy.

Halo Nevi

The halo nevus describes a stage of a clinical phenomenon where the host body rejects the involved melanocytes as well as the normal pigmented cells immediately surrounding the nevus. They usually occur on the back of children and may be associated with preexisting junctional nevi. The halo nevus presents as a central pigmented lesion that is well delineated and surrounded by a margin of depigmented, pale skin, resembling a “halo.” Left alone, these lesions often entirely resorb.

Compound Nevi

As melanocytes descend, they are found at both the dermoepidermal junction and within the dermis, thus a *compound nevus*. It often contains small amounts of hair and tends to be a lighter brown, circumscribed, slightly raised lesion characteristic of the typical adult “mole.” There does not appear to be a significantly increased risk for melanoma, and observation is the rule, unless cosmetic concerns exist. It “matures” into the classic intradermal nevus of adults.

Intradermal Nevi

With intradermal nevi, melanocytes are found exclusively in the deeper dermis and represent the common, non-pigmented nevus found in many older adults, especially on the face and scalp areas. The nevi can contain small tufts of hair, and they have the least malignant potential of the subtypes of nevi. The clinical presentation is varied and may be flat, raised, or even pedunculated, dark brown in color or entirely without pigment, smooth or

rough in texture. Treatment is usually cosmetic and best managed with a superficial shave excision. When hair is present, it implies deeper involvement, and an elliptical or punch excision may be warranted.

Sebaceous Nevus

The sebaceous nevus of Jadassohn does not originate from neural crest melanocytes but is a congenital nevus frequently found on the scalp of young children. It appears as a yellow, fleshy, pebbly lesion that is well demarcated and without hair (Fig. 2–13). Size can vary from a few millimeters to several centimeters in diameter. The nevus is usually circular in shape, although a linear form can be found on the face. Histologically, one finds a hypertrophy of sebaceous glands within the dermal layers and a hyperplasia of the epidermis. The nevus has three clinical phases: (1) at birth the sebaceous glands appear normal; (2) during childhood the glands reduce in number and size, making the lesion more inconspicuous clinically; (3) at puberty the glands undergo a rapid hypertrophy and the lesion appears to enlarge. It is during this third phase that cutaneous malignancies can arise, especially BCCAs, which have been reported in as many as 5 to 7% of patients with sebaceous nevi.¹¹ For this reason, the treatment of choice for sebaceous nevi is complete excision before puberty. Appendicular tumors such as syringocystadenoma also occur within these nevi.

Blue Nevus

Blue nevi are less common and appear as smaller, hairless lesions on the face and neck of older individuals. The melanocytes are often found in deeper layers, including into the subcutaneous fat, thus giving rise to the deep blue color and requiring deeper excision for treatment.



FIGURE 2–13 Nevus sebaceous of scalp in a child. (See Color Plate 2–13.)

Spitz Nevus

The Spitz nevus is an uncommon lesion more often found in children, also known as a “juvenile melanoma.” It tends to be rapid growing, found on all parts of the body, and has a pink or even red tint to it. Most lesions are raised or dome shaped and firm to palpation. They are difficult to distinguish from a malignant melanoma, although true malignant degeneration is not seen. Treatment is dictated by clinical suspicion, and once the diagnosis is confirmed, it can be managed with aesthetic priorities.

Lentigo Senilis

This is also known as “solar lentigos,” “actinic lentigos,” or “liver spots.” It is a very common lesion appearing as a light brown, macular spot with an irregular border found on sun-exposed areas, particularly the hands and face of older individuals. On rare occasion, several lesions may coalesce to create a single larger lesion. It has no malignant potential and is often confused with *seborrheic keratosis*. Treatment is best with chemical agents such as deeper peels or bleaching agents. Cryotherapy is an alternative option.

Lentigo Maligna

Lentigo maligna is a precursor to the malignant melanoma and can be considered an intraepithelial in situ melanoma with the potential for progression into an invasive lentigo maligna melanoma. These lesions also occur on the sun-exposed surfaces of elderly individuals and are thought to carry about a 5% risk of becoming a frank melanoma. This progression of disease is thought to be heralded by a change in contour with a nodular area developing within a previously flat lesion. Treatment is surgical excision with a 5-mm margin peripherally and down to the subcutaneous fat. It must be recognized that the final pathologic review may uncover a malignant melanoma within the specimen, in which case the margin would have been inadequate and reexcision is warranted.

Malignant Melanoma

Malignant melanoma is the third most common skin cancer but an entirely different entity in many ways, the most significant being the prognosis and its potentially lethal outcome; it is responsible for over three quarters of all deaths from cutaneous malignancies and has the No. 1 fastest growing incidence in the United States. Like the other cutaneous neoplasms, it tends to occur on sun-exposed areas; however, malignant melanomas do not adhere to this rule as consistently. Because most adults have scattered benign pigmented lesions, early and accurate diagnosis is often delayed. There are four distinct clinical characteristics for melanoma (A to D), and a change in them over several months is a particularly ominous sign: A stands for asymmetry in topography or shape; B stands for the border of the lesion, which



FIGURE 2-14 Malignant melanoma. Note the asymmetric topography, irregular borders, color variegation, and satellite lesions. (See Color Plate 2-14.)

may be irregular; C stands for color variability within the lesion; and D stands for diameter, as in larger lesions (>6 mm) or a change in size. Finally, *satellite* lesions around the primary tumor raise the suspicion for a malignant melanoma (Fig. 2-14).

PEARL... Malignant melanoma is characterized by ABCD: asymmetry, border irregularity, color variation within the lesion, and a diameter that recently changed or is greater than 6 mm.

Definitive diagnosis is made histologically with special immunohistochemical stains for cells of neural crest origin, i.e., S-100 or HMB-45.

Different subtypes of malignant melanoma exist and reflect different growth patterns. *Superficial spreading* is the most common and usually has the characteristic signs of color variability, irregular borders, and nodularity. The radial growth phase usually precedes the vertical phase for a variable period of time. *Nodular* melanoma is the most aggressive subtype, having an early vertical growth phase. Fortunately, it is not common, occurring in less than 10% of melanoma cases. *Lentigo maligna melanoma* has the best prognosis and is most often found on sun-exposed areas of elderly patients. It evolves from the benign precursor, lentigo maligna, also known as the “Hutchinson’s freckle,” and may grow in a radial fashion up to several centimeters. *Acrall lentiginous* is the most common melanoma subtype in African Americans, usually occurring on the acral surfaces such as the hands, feet, and anogenital mucosa. Although its prognosis is quite poor, it only makes up 5 to 7% of melanomas.

Prognosis is most determined by tumor depth, and the staging classification has recently been revised to

incorporate better tumor ulceration, regional metastasis, and tumor depth. The Clark level, describing tumor thickness based on histologic layer, e.g., papillary dermis versus reticular dermis, has been limited to only the smallest lesions. The Breslow thickness (measured in millimeters from the basal layer of the epidermis) has greater prognostic significance, and because the depth is so critical in staging, an accurate biopsy must include the deep margin. Tumor ulceration can influence this vertical measurement but it is now accounted for and its mere presence will advance the tumor stage. The current staging system also uses whole numbers for depth of invasion: stage I, <1 mm; stage II, 1 to 2 mm; stage III, 2 to 4 mm; and stage IV, >4 mm (Table 2-3).

The primary treatment for malignant melanoma is wide local excision, but there is a trend toward decreasing the margin.³⁰ For melanoma in situ, a 5-mm margin is adequate. Tumors less than 1 mm in depth are excised with a 1-cm margin, whereas those greater than 1 mm in vertical depth should have a 2-cm margin, even on the face. Regardless of depth, a margin in excess of 2 cm has not lowered recurrence rates or improved survival.^{30,31} Melanomas in excess of 4 mm in depth have a 5-year survival rate of less than 50%, and this statistic does not change with wider excisional margins.^{32,33} The best management for potential lymphatic spread is unclear, but it is generally accepted that for lesions greater than 4.0 mm in vertical depth, a staging/prophylactic neck dissection should be performed. For lesions between 0.75 and 4.0 mm in depth, intralesional lymphoscintigraphy with sentinel node biopsy may prove to be effective.³⁴⁻³⁶ Lesions less than 0.75 mm are usually managed locally only.

LOCAL AND REGIONAL CUTANEOUS FLAPS

FLAP PHYSIOLOGY

The creation of cutaneous flaps disrupts the normal vascular network and an alternate flow is immediately established. In the face and neck, the subdermal arcade is typically robust enough to allow one to place significant tension and stress on the pedicle without jeopardizing the skin paddle. It has been long believed that a wider pedicle base allows for greater vascular inflow and that the length of the flap is dictated by its width, thus giving rise to the dictum of a minimum length/width ratio of 3:1. The fallacy of the length/width ratio has been demonstrated, and it is currently accepted that the *perfusion pressure* at the flap base is the most significant variable in terms of ensuring flap viability.^{37,38} This understanding has directed the development of ways to enhance flap perfusion and viability. The forehead flap is an example of how a long, narrow pedicle can support a flap through its rich perfusion pressure at the pedicle base.

A second important understanding in flap physiology is the recognition of *venous congestion* and the impact it

TABLE 2-3 THE REVISED AMERICAN JOINT COMMITTEE OF CANCER (AJCC) STAGING SYSTEM FOR CUTANEOUS MELANOMA

Stage	Characteristics
IA	Tumor ≤ 1.0 mm without ulceration; no lymph node involvement; no distant metastases
IB	Tumor ≤ 1.0 mm with ulceration or Clark level IV or V
IIA	Tumor 1.01– 2.0 mm without ulceration; no lymph node involvement; no distant metastases
IIB	Tumor 1.01– 2.0 mm with ulceration
IIIA	Tumor 2.01– 4.0 mm without ulceration; no lymph node involvement; no distant metastases
IIIB	Tumor 2.01– 4.0 mm with ulceration
IIIA	Tumor >4.0 mm without ulceration; no lymph node involvement; no distant metastases
IIIB	Tumor >4.0 mm with ulceration; no nodal involvement; no distant metastases
IVA	Tumor of any thickness without ulceration with one positive lymph node and micrometastasis ^a or macrometastasis ^b
IVB	Tumor of any thickness without ulceration with two to three positive lymph nodes and micrometastasis ^a or macrometastasis ^b
IVC	Tumor of any thickness and macrometastasis ^b OR in-transit metastases/satellites without metastatic lymph nodes, OR four or more metastatic lymph nodes, matted nodes, or combinations of in-transit metastases/satellite(s), OR ulcerated melanoma and metastatic lymph node(s)
IV	Tumor of any thickness with any nodes and metastases

Note: Ulceration is the absence of an intact epidermis overlying a portion of the primary melanoma based on pathologic microscopic observation of the histologic sections.

^aMicrometastases are diagnosed after elective or sentinel lymphadenectomy.

^bMacrometastases are defined as clinically detectable lymph node metastases confirmed by therapeutic lymphadenectomy or when any lymph node metastasis exhibits gross extracapsular extension.

has on flap toxicity. Cutaneous flaps of the face are more likely to suffer from venous congestion than arterial ischemia, and its distinction and prompt intervention is imperative. There are several ways to address acute venous congestion of a flap, e.g., medicinal leeches, hyperbaric oxygen, release of skin sutures, or returning the flap to its site of origin. (Flap salvage is further discussed later in this chapter.)

Methods of enhancing flap viability are of great clinical interest and have been widely studied. *Flap delay* is a time-tested way of improving viability, and its efficacy is reproducible. “Delay” is accomplished by incising around the border of the intended flap as a preliminary stage, or alternatively elevating a portion of the flap but immediately replacing it back to the donor site. The definitive stage is performed 7 to 14 days later. Although the impact of improving flap perfusion can be dramatic, its mechanism of action remains poorly understood with conflicting hypotheses.^{39–46} Theories include the creation of arteriovenous shunts around the perimeter, enhancing collateral revascularization along the long axis of the flap, exhausting the transient adrenergic spasm that follows the initial skin incision, and a metabolic adaptation that might occur at the cellular level of the skin paddle.

Hyperbaric oxygen therapy is the systemic administration of 100% oxygen under pressure of 2 to 2.5 atm and has been shown to improve flap viability through two primary mechanisms.⁴⁷ First, a dramatic rise in dissolved plasma oxygen concentration occurs and directly increases oxygen tissue diffusion and target saturation. The increase in dissolved plasma oxygen is so dramatic that it overcomes the fact that, under normal conditions,

only minor oxygen delivery is achieved through plasma in comparison to hemoglobin bound oxygen. Second, by amplifying the ischemic gradient along the flap, neovascularization is accelerated along the axis of the flap. Clinically, hyperbaric oxygen can be useful in two scenarios. After a flap or graft is transposed and the clinical appearance is marginal, because of either arterial ischemia or venous congestion, the immediate treatment with hyperbaric oxygen can salvage the flap. Twice-daily dives are used and frequent clinical checks should be performed because once flap necrosis has occurred, further treatment is not warranted. The second situation is the prophylactic treatment of a flap within compromised tissues, such as an irradiated bed. Such tissue is characterized by chronic hypoxia, hypocellularity, and vascular sclerosis. Preoperative treatment with 20 dives, followed with 10 postoperative dives, is a protocol extrapolated from experience with dental extractions in the irradiated mandible. It should be noted that hyperbaric oxygen has no effect when applied topically and offers no benefit to normal tissues.

Pharmacologic intervention can improve survival of marginal flaps but its widespread clinical use has not been seen. Pharmacologic enhancement is more routinely practiced with microvascular flaps than with cutaneous facial flaps. Both heparin and dipyridamole have demonstrated a positive effect on ischemic flaps, presumably through anticoagulation and the prevention of small clots in the microvasculature.^{48,49} *Rheologic agents* such as pentoxifylline can improve red cell pliability and, in theory, enhance flow through terminal vessels and into a marginal flap.^{50–53}

FLAP NOMENCLATURE

Flap nomenclature should be precise and used consistently among all surgeons performing this type of surgery. There are four general systems for classifying cutaneous flaps: (1) blood supply, (2) tissue content, (3) area of recruitment, and (4) method of transfer.

Blood Supply

Random donor flaps are based on the rich vascular network of small vessels within the dermal layer. They are the basis of most local cutaneous flaps and are generally quite dependable within the head and neck. *Axial pattern* flaps are nourished by small vessels in the dermal or subcutaneous level that are of larger caliber and run in an axial pattern through the length of the flap. An inferiorly based melolabial flap is an example of a flap based on an axial pattern vascular supply. Flaps that are primarily nourished by a named vessel of larger caliber are classified as *pedicled* flaps. They can be extended indefinitely as long as the named vessel remains incorporated within the body of the flap and the skin paddle follows the cutaneous angiosome. They can be transferred as a microvascular “free” flap to a distant location and the temporoparietal and pectoralis flaps are examples.

Tissue Content

Tissue content is another means of distinguishing flaps. *Cutaneous flaps* consist of skin (and its underlying subcutaneous fat). Most random flaps of the face are “cutaneous” flaps. *Fasciocutaneous flaps* include the underlying fascia, which is usually incorporated with the flap because it carries a larger caliber vessel, thus improving dependability. The deltopectoral flap is such an example. When the muscular layer is also included, the *musculocutaneous flap* brings a named muscular vessel that supplies the overlying skin through direct perforating branches. *Composite flaps* refer to flaps that carry more than one embryologic layer, i.e., ectoderm and mesoderm. In practical usage, however, composite flaps imply the transfer of bone, and a composite graft includes skin and cartilage.

Area of Recruitment

The region from which the flap originates is another means of classifying different flaps. *Local* flaps come from tissue adjacent to the primary defect and include such common flaps as the rhombic and bilobe flaps. *Regional* flaps originate from areas that are not juxtaposed to the defect yet usually are from within the same anatomic site, such as within the head and neck. An axial pattern forehead flap for nasal reconstruction is an example of a regional flap. *Distant* flaps imply transfer of tissue from one region of the body to another, such as a microvascular forearm flap or pectoralis myocutaneous flap.

Method of Transfer

Describing the method of transfer is probably the most widely used yet frequently misunderstood system. *Advancement* flaps are the simplest form of tissue mobilization and imply the transfer of skin in a unilinear direction with a single vector of tension. Primary closure of a wound utilizes bilateral advancement flaps of a simple form. *Rotation* transfers tissue around a fixed pivot point and is rarely used in this strict sense. Scalp reconstruction may be the rare occasion where a pure rotation flap is used. Most cutaneous flaps of the face employ elements of both advancement and rotation, capitalizing on the intrinsic extensibility of facial skin. *Transposition* is the mobilization over an incomplete bridge of skin; a transposition flap must travel over a small segment of skin to reach the primary defect, such as occurs with a bilobe or rhombic flap. Advancement and rotation flaps, on the other hand, originate entirely from adjacent areas without crossing over a peninsula of skin. *Interposition* flaps are similar to transposition except the “incomplete bridge of skin” is also elevated and transferred in an opposing direction, e.g., a Z-plasty. *Interpolation* refers to the transfer of skin over an *intact* bridge of skin and implies a two-stage procedure with future pedicle division. A traditional forehead flap is an interpolated, axial pattern flap when transferred over the intact skin of the glabella. An island flap is a modification of an interpolated flap as the pedicle is de-epithelialized and tunneled under the intact bridge of skin between flap and defect. The pedicle is not as robust but the flap is transferred in a single stage. “Free” microvascular flaps are defined by the dissection and division of the vascular pedicle with flap transfer and subsequent anastomosis to a second vascular complex.

DEFECT ANALYSIS

A reconstructive algorithm with which to approach facial cutaneous defects can be a useful tool when searching for the optimal local flap. Four issues—landmarks, facial lines, area of recruitment, and resultant scars—should be considered before all surgical repairs are done, and a systematic approach during this analysis can help avoid unexpected distortions and untoward results.

Defect analysis should answer four questions:

1. Which surrounding landmarks must not be distorted or subject to tension? These must be identified at the outset because they will eliminate flaps that pull from important facial structures, such as the eyelid, nasal ala, oral commissure, and hairline. Recognizing this concept leads us to close eyelid defects vertically rather than horizontally, in spite of the existing horizontal facial creases that may exist.
2. From what region around the defect is there maximal laxity and opportunity for tissue recruitment?

The optimal area of recruitment is influenced by the structures that are immobile and by general skin excess and extensibility. They do not always correspond with line of maximum extensibility.

3. How are the “facial lines” of that region oriented, including the lines from the borders of aesthetic units and subunits? Facial lines are numerous and specifically defined in terms of their etiology. *Langer’s lines* were originally described when circular wounds created in fresh corpses assumed an elliptical shape as rigor mortis ensued. It was assumed that this phenomenon was due to residual skin tension and that wounds created parallel to such ellipses would heal more favorably.⁵⁴ *Relaxed skin tension lines* (RSTLs) are derived from the intrinsic vectors of tension within the cutaneous dermis, independent of extrinsic forces such as gravity and muscle; it is a reflection of the molecular orientation in the dermal level. They usually run perpendicular to the muscular fibers beneath them. *Lines of minimum tension*, also called facial creases or wrinkles, are lines created by the repeated action of the underlying muscle and are usually visible. Although they often parallel the traditional RSTLs, it is not always the case, and they are distinct entities. Three areas of conflict between lines of minimum tension and RSTLs are the glabella, lateral canthus, and nasal supratip (Fig. 2–15). When in conflicting areas, it is

more favorable to orient scars along facial creases rather than RSTLs. *Skinfolds* refer to the deep lines created as excess skin tumbles over adjacent areas, such as the melolabial fold and marionette lines around the oral commissure. *Sleep lines* arise from habitual sleep positions that cause permanent facial creases.

The *aesthetic units* principle has had a significant impact on facial reconstruction in terms of creating inconspicuous results by modifying a cutaneous defect, adjusting flap size and shape, and ultimately controlling the exact location of scars. This concept is based on the fact that all things are viewed as a series of block images that are assembled subconsciously and interpreted as a single picture. An example of this is the saccadic way in which our eyes pan across a room. Each block image is then assembled into a complete picture at a higher cerebral function. A line or scar that lies between two consecutive images can easily go unnoticed and is the basis of the aesthetic units principle in facial reconstruction. The face is viewed as a series of block images that are subconsciously put together; lines, wrinkles, or scars that lie between adjacent units not only are inconspicuous but also may be even expected. Facial aesthetic units and subunits have been defined (Fig. 2–16).

4. What vectors of tension are created during transposition of the flap, and what will the resultant scar be? These must be anticipated and viewed with respect to regional facial lines, aesthetic units, and immobile landmarks, and may not always be immediately intuitive. The tension created to the alar rim during the rotation of a bilobe flap must be thought through in advance. A rhombic flap is an example where the resultant scars are not straightforward but are consistent. (See later for further discussion.)



FIGURE 2–15 Relaxed skin tension lines (RSTLs) and lines of minimal tension (wrinkles) used for designing facial incisions. Three areas of conflict are the glabella, lateral canthus, and nasal supratip.

PEARL... Defect analysis should address four issues: (1) immobile surrounding landmarks, (2) pre-existing lines (wrinkles and aesthetic units), (3) area of recruitment, and (4) resultant scars for each flap.

Second-Intention Healing

Second-intention healing remains a simple and safe means of managing many cutaneous wounds and can still represent the most aesthetic repair. Mohs’ surgery originally used second-intention healing exclusively with in situ permanent tissue fixation, followed by histologic examination.⁵⁵ This technique took several days and mandated second-intention healing. With the advent of freeze fixation, immediate tissue examination became possible and opened the door for prompt wound closure, thus catalyzing the interest and refinement of local flaps.

Normal wound healing, whether from second-intention repair or following closure of a laceration, occurs through four distinct phases: (1) coagulation, (2) inflammation,

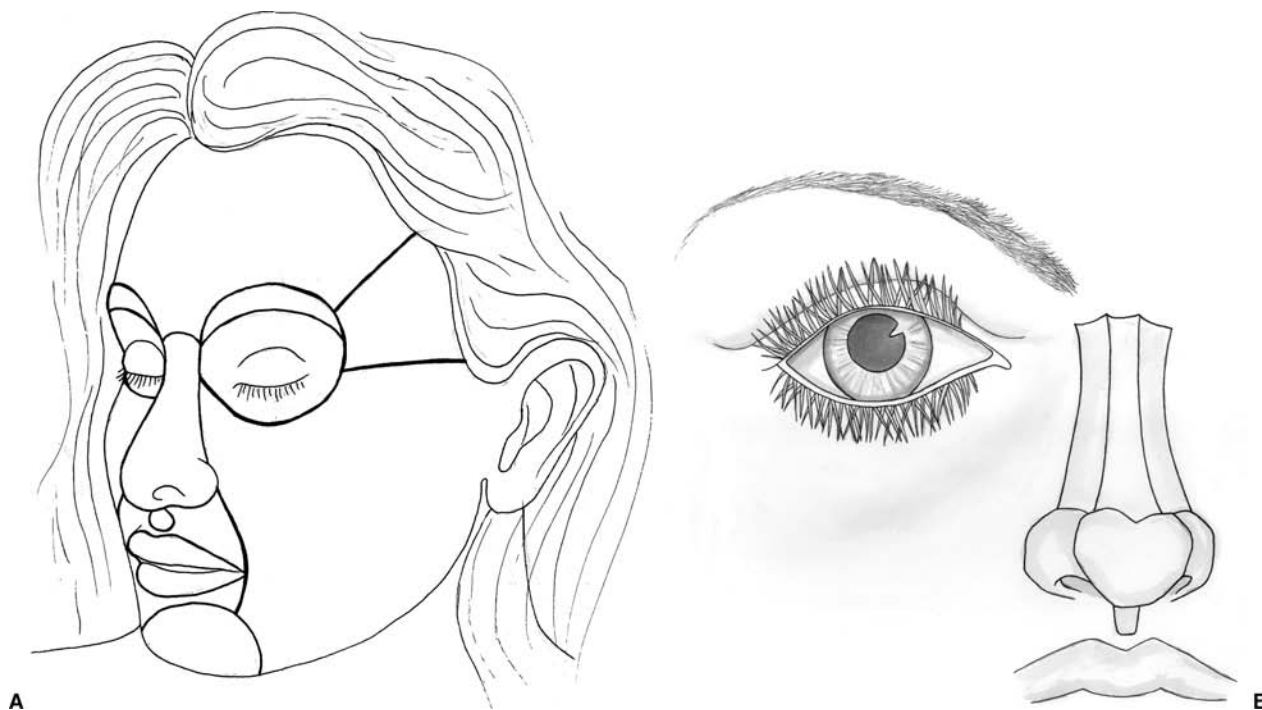


FIGURE 2-16 (A) Aesthetic units. (B) Nasal subunits.

(3) proliferation, and (4) maturation. The *coagulative phase* involves the initial platelet plug with hemostasis and is completed within the first few minutes. The *inflammatory phase* lasts for 7 days and is associated with vasodilatation, neutrophil and macrophage infiltration, and surrounding erythema. The *proliferative phase* represents cellular division and is the principal stage of wound healing, beginning within the first few days and lasting for about 4 weeks. Granulation tissue is one of the first signs of the proliferative stage, representing the onset of vascular angiogenesis, inflammatory cell influx, and fibroblasts. Epithelial proliferation occurs from wound margins as well as from deeper pilosebaceous units (when they exist). This process proceeds most rapidly when maintained in a moist environment, as opposed to a dry eschar.⁵⁶ The exact stimulus for epithelial regeneration is poorly understood but is certainly influenced by the large number of growth factors released during the inflammatory phase. Wound strength is achieved at the dermal layer from the proliferation of fibroblasts and their production of collagen and elastin fibers. This period is characterized by a red and raised cutaneous wound or scar, usually peaking at about 2 to 3 weeks. The fibroblasts later evolve into myofibroblasts, the key cell responsible for the critical wound contracture. This event is characterized by the centripetal contracture and is a power force that can greatly reduce a wound size, but it also can create secondary facial deformities. The final stage is *wound maturation* and occurs from about 1 month and continues for a year. During this period, reorganization of dermal elements and increasing wound strength

can be seen. Externally, the scar appears softer, flatter, and with more normal color and texture match.

Because of contracture, the use of second-intention healing must be selective and free from distortion of surrounding *immobile* structures such as the nasal alae or eyelid. Superficial defects less than 1 cm and on concave surfaces are ideally suited for such methods, such as on the medial canthus, triangular fossa of the ear, or supralar crease. Larger wounds on the upper forehead and scalp can also be managed with second-intention healing, benefiting from the contracture that occurs. Deeper wounds leave a contour irregularity, and the depression should be anticipated. Consideration should also be given to the duration of healing and necessary wound care with respect to other options for repair; second-intention may take numerous weeks to epithelialize, whereas a skin graft or local flap may be healed and presentable at as early as 2 weeks.

Skin Grafts

Graft Viability

Skin grafts are a simple and effective means of managing many superficial defects of the face and neck. The process of graft "take" occurs through a series of stages defined by the method of nutrient supply and vascularization. The initial period is known as plasma imbibition, occurring during the first 48 hours, where the graft obtains nutrients through direct diffusion from the recipient bed rather than through vascular channels. Inosculation is the process by which host vessels grow into exiting

vascular channels within the graft. It is a minor contributor to graft vascularization and occurs during the first few days.⁵⁷ The next stage is neovascularization, where new vessels proliferate and penetrate the graft, taking place between the second and seventh day. The final stage is organization with fibroblast proliferation, collagen matrix production, and firm anchoring of the graft to the recipient bed. This stage occurs during the second week and continues for several months. Neural regeneration may also occur into the skin graft but is usually incomplete.

Graft Thickness

Skin graft thickness is an important consideration and several distinct characteristics exist for them. A *split-thickness graft* is defined by a harvest from within the dermal layer, thus leaving behind deeper dermal elements as well as pilosebaceous units that allow primary reepithelialization of the donor site. This can be an advantage when large amount of skin are needed, such as with major burns, but is often associated with greater morbidity, duration of recovery, and unfavorable scarring. *Full-thickness grafts* are taken from the subcutaneous plane and include the entire dermal/epidermal components; it implies a secondary procedure for donor site closure. In addition to the method of managing the donor site, there are important distinctions between full- and split-thickness grafts. The following characteristics also apply to different thicknesses of split-thickness grafts:

1. Immediate contracture: immediately after harvest, all skin grafts contract from their original size and thicker grafts do so more than thinner ones. The degree of elastic fibers within the dermis of the graft influences this process and can be overcome with stretching or pie-crusting (described later in this chapter).
2. Delayed contracture: after repair, even a grafted wound undergoes contracture, albeit less than wounds allowed to heal via second-intention. Thicker grafts contract less.
3. Viability: thinner grafts have better survival than thicker ones, as can be expected given the early methods of nutrient supply. In the head and neck, however, excellent graft take is the rule and expected in nearly all circumstances.
4. Color and texture match: this is usually the strongest consideration in facial reconstruction. Full-thickness grafts, especially those harvested from the face and neck, can produce an excellent cosmetic result. Very thin grafts and split-thickness grafts result in a pale and glossy appearance that is often conspicuous. Even thicker grafts, however, cannot overcome contour depressions.
5. Donor site: split-thickness grafts allow primary epithelialization of the donor site, whereas full-thickness grafts require direct closure.

Technique

The recipient wound is prepared by aggressive beveling of the edges toward the center of the defect to blend the transition between graft and host. A “purse-string” partial closure can decrease the size of the defect substantially while creating small standing cutaneous deformities that can be a source of skin for grafting. Circular defects are often converted to a rectangular shape with sharper corners as they tend to be more inconspicuous. Contour problems from a defect depression can be improved by a 10- to 14-day delay in repair, allowing granulation tissue to form and fill in the recipient bed. When small areas of nonvascularized tissues are within the wound, such as foci of bare cartilage in the ear, one may be able to excise judiciously without compromising the structural support. Alternatively, a delay may permit granulation tissue to grow over the cartilage/bone and improve the receptiveness of the bed. On rare occasion, a second, vascularized fascial flap may be mobilized to cover the denuded structure and support the skin graft.

Split-thickness grafts are usually harvested with a dermatome at thickness between 10 and 15/1000 of an inch. Full-thickness grafts are taken with a scalpel in the immediate subdermal plane and require primary closure. Common donor sites for full-thickness graft harvest include upper eyelid (for extremely thin grafts), pre- and postauricular skin, melolabial fold, and supraclavicular areas. The graft can be “pie-crusting” to allow the egress of fluid and serum from between the graft and donor site. These small holes, however, can leave small scars or texture discrepancies that remain apparent in the future. Close apposition is imperative and can be achieved with either a moist bolster dressing or small “tacking” sutures from the graft to the recipient bed. Wound care is imperative with liberal lubrication. Cleaning with hydrogen peroxide is avoided due to its cellular toxicity.

Advancement Flaps

An advancement flap is mobilized in a single vector and can be unilateral or bilateral. The simplest form of such a flap is seen with primary closure after lateral undermining. The apices of the ellipse should extend sufficiently to be less than 30 degrees to avoid large standing cutaneous deformities. An alternative to extending the flap is to close the apex with an M-plasty. A Gillies stitch at the apex can pull the terminal triangle toward the center and avoid a “pin cushion” deformity there (Fig. 2–17). More elaborate advancement flaps are indicated when the direction of pull must be along a precise axis with minimal or no tension to the surrounding areas, such as above the eyebrow. Pure advancement flaps are uncommon because many have some rotational element to them. The vasculature of the flap is dependent on the plane of elevation and can vary between random patterns to axial patterns. After the primary defect is closed, the secondary defects, those created by elevation and

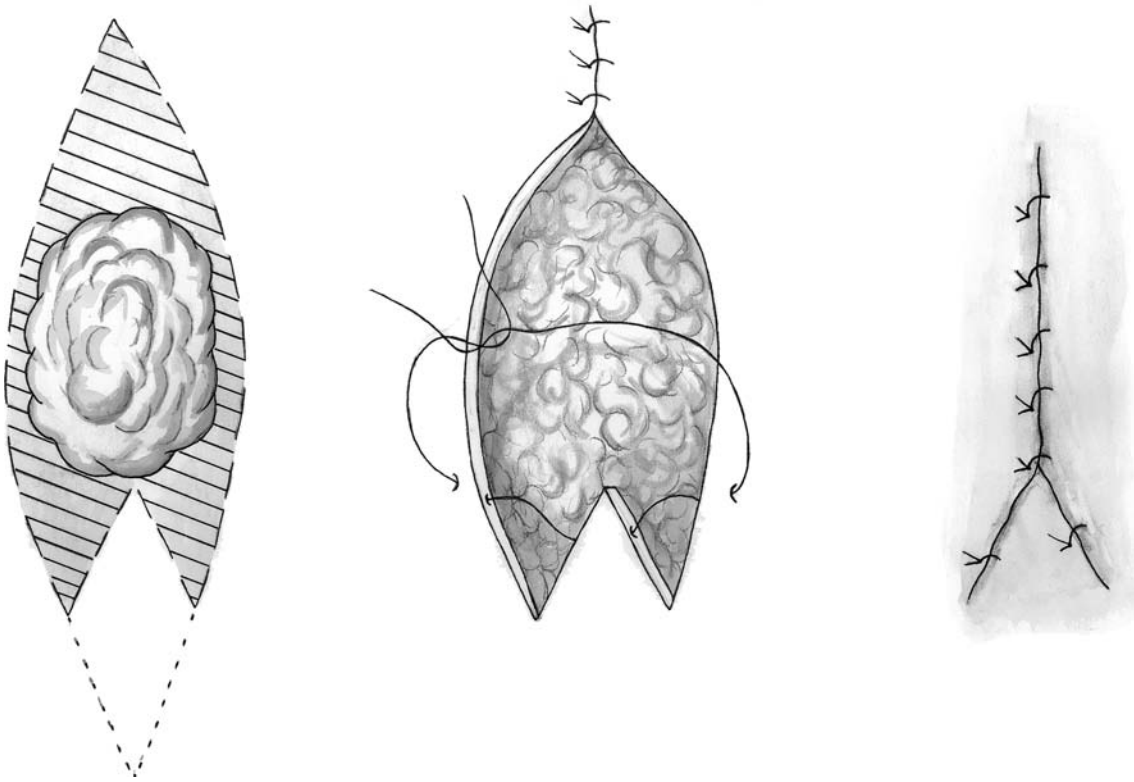


FIGURE 2-17 Primary closure with an M-plasty at the apex. The Gillies stitch pulls the triangular flap toward the center.

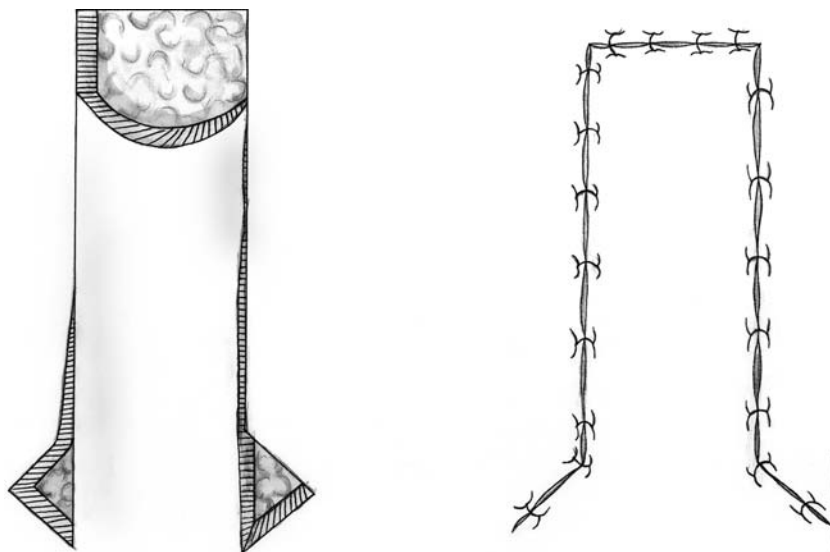


FIGURE 2-18 Unilateral advancement flap with direct excision of standing cutaneous deformities.

mobilization of the tissues, are on either side of the flap and are crescent shaped with two edges of unequal length. Closure of these sites can be done with the “halving” technique or direct excision of the standing cutaneous deformity (“dog ear”) (Fig. 2-18). Advance excision of the “Burrow’s triangle” is not advised because the exact size is difficult to predict. Moreover, one can

move the standing cutaneous deformity to different areas of the incision and modify the angulation of the resultant scar to best camouflage it.

The V-Y flap is a form of a unilateral advancement flap that creates very little distortion around the primary defect. The triangular flap is based on a subcutaneous pedicle and advanced in a linear direction toward the



FIGURE 2-19 Case 1. V-Y flap for a 1-cm defect involving the upper lip and columella. (A) V-Y flap designed. (B) V-Y advancement flap to fill the lip portion of the defect. (C) Six-month follow-up.

defect. The donor site is then closed primarily, creating a resultant scar that is in the shape of the letter Y. These flaps have limited reach due to the subcutaneous pedicle and are therefore ideally suited for smaller defects adjacent to critical landmarks (Fig. 2-19).

Rotation Flaps

Pure rotation flaps pivot around a fixed point and are uncommon flaps in the face and neck because most also have a translational movement to them. In general, the arc of the flap is about four times the diameter of the defect and the radius about 2.5 times. The pivot point is at least 1.5 times from the wound margin to avoid a residual standing cutaneous deformity (Fig. 2-20). Increasing the radius of the flap creates more rotational movement and less advancement. The Burrow's triangle adjacent to the primary defect is excised last to determine the accurate amount of discarded tissue. The donor site defect has wound edges of unequal length and can usually be managed with serially halving sutures. A "back cut" at the distal aspect of the flap facilitates transposition but may compromise the flap pedicle.

The most common site for pure rotational flaps is the scalp. The lack of extensibility of this tissue lends itself to rotational vectors, although an arc of six times the defect diameter is often needed. Small defects of the nose can be repaired with local rotational flaps from adjacent nasal skin.

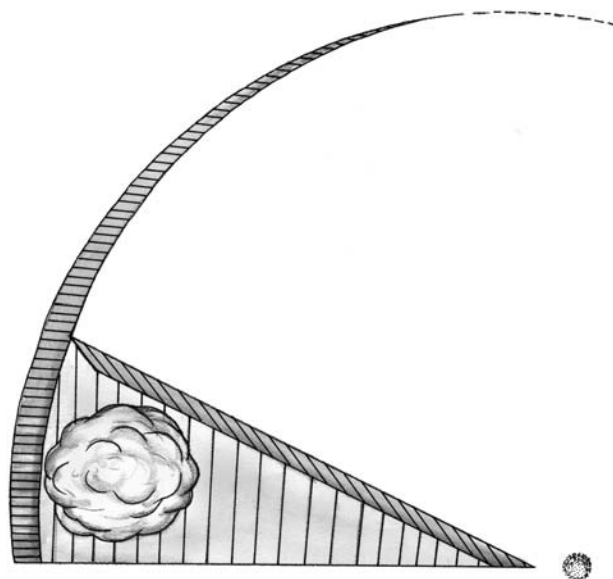


FIGURE 2-20 Rotational flap with little tissue advancement. Standing cutaneous deformity is directly excised.

ADVANCEMENT/ROTATION FLAPS

The *O-T flap* incorporates vectors of rotation and advancement and is useful when the closure must avoid all tension along one aspect of the primary defect. Tissue recruitment is from either side of the circular wound, with direct excision of a central standing cutaneous



FIGURE 2-21 Case 2. O-T flap for a 1.5-cm defect of the left forehead. (A) Flaps designed with anterior hairline marked. (B) Defect closed with resultant scar in a T configuration.

deformity. The resultant scar converts the circle into the letter T (Fig. 2-21). Wounds near the eyebrows or hairline are often repaired with some form of O-T closure. The resultant scar has two perpendicular limbs, making it difficult to orient along favorable lines.

The *cheek flap* is an advancement/rotation flap that utilizes the extensibility of skin from the cheek and is ideally suited for cutaneous defects of the medial cheek areas. It has a wide pedicle base, and additional skin can be recruited from the postauricular area and transposed as a large “bilobe” flap. Several specific points in flap design are made: (1) Incisions should follow the borders of aesthetic units, with the exception of the lower lid, where a subciliary scar is often better concealed than one along the infraorbital rim. In the lateral canthal area, the tendency to drift inferiorly should be resisted, as a high arc incision allows more of a rotational element to the flap. The medial canthal portion of the incision should not be rounded but a sharp corner maintained. The medial aspect of the flap is along the nasal-facial junction, which is vertical in orientation and somewhat higher on the nose than expected. The medial/inferior aspect is within the melolabial fold. There is a tendency for the melolabial fold to bunch up after flap rotation. To minimize this, one should trim an appropriate amount of redundant skin as well as directly excise a layer of subcutaneous fat from the ptotic malar fat pad. (2) The plane of elevation is the subcutaneous layer, superficial to the facial nerve and subcutaneous musculoaponeurotic system (SMAS). (3) Additional thinning of the flap can be performed in the area being transposed to the lower eyelid, allowing better contour match. (4) Avoiding lower lid retraction is paramount and is achieved by anchoring the flap to the periosteum of the maxilla and malar eminence. A long-acting resorbable suture is best for this purpose. When significant medial tension is created, it may be necessary to anchor the flap to the bony pyriform aperture through small drill holes. Lid shortening procedures may still be needed when significant laxity preexists (Figs. 2-22 and 2-23).

Transpositional Flaps

These are cutaneous flaps that are mobilized over an incomplete bridge of skin. The *rhombic flap* is a classic advancement/rotation transposition flap with great versatility in the repair of small cutaneous defects of the face. The design, vectors of tension, and resultant scars are predictable and reproducible. The traditional Limberg rhombic flap is designed with specific angles and line segments, thus making for a precise geometric shape and consistent results⁵⁸ (Fig. 2-24). The transposed flap has a significant amount of tension (58%) at a single point and the flap should be oriented such that this tension is along lines of maximal extensibility.⁵⁹ The resultant scar runs in multiple directions and does not all lie within favorable wrinkles. One problem with the Limberg flap is the degree of rotation required and the standing cutaneous deformity that could arise at the apex of the defect. The *Durfourmental* modification allows for a smaller arc of rotation through a narrower flap harvested closer to the primary defect⁶⁰ (Fig. 2-25). This modification distributes more tension around the perimeter of the flap. Another concern with the Limberg flap is the amount of normal tissue that has to be discarded at the corners of the rhombic defect. The *Webster 30-degree* modification creates an M-plasty at the apex and preserves more tissue⁶¹ (Fig. 2-26). This design also leaves a more complex scar that is not always desirable.

The *bilobe* is a workhorse transposition flap for many smaller defects as it allows repair with minimal distortion to the defect periphery by diverting the closure tension further away through a second local flap. It is ideally suited for defects that are adjacent to immobile structures such as the alar rim, where tissue recruitment and tension from closure can be shifted to the middle third of the nose. Earlier designs arranged each lobe at 90-degree angles to one another, leaving a significant arc of rotation, a larger standing cutaneous deformity, and a narrower flap pedicle. Refinements of flap design placed each lobe closer together, i.e., 45 to 50 degrees, allowing for a tighter



FIGURE 2-22 Case 3. (A) Bilobe cheek flap for a large left cheek defect. (B) Bilobe cheek flap design. (C) Flap transposed utilizing postauricular skin. (D) Six-month postoperative result.

arc of rotation⁶² (Fig. 2-27). Further modification of the flap can convert the secondary defect into a triangle, allowing the triangular secondary flap to lie flat without trimming its corner. The resultant scar with the secondary flap is a triangle rather than lobule, leaving a more inconspicuous scar and contour. The primary flap should be aggressively thinned to minimize the effects from wound contracture and subsequent pin cushioning. If this contour problem arises, conservative amounts of steroids injected within the lobule can expedite its resolution. One may be able to orient the flap such that the secondary donor site, which is closed primarily, leaves a vertical scar rather than an oblique one. This tends to be more discreet by running along borders of aesthetic subunits.

The *melolabial flap* can be transferred as either a single-stage transposition flap or a two-stage interpolated

flap (see below). As a transposition flap, it is suited for smaller defects of the lateral and caudal nose, such as the nasal sidewall and alar lobule. It is usually a superiorly based, random donor flap from tissue lateral to the primary defect, and the donor site is closed primarily. A Burrow's triangle is excised from the superior aspect of the defect. A few aesthetic problems often arise from this flap: (1) the natural supra-alar crease is obliterated; (2) the nasal-facial junction is blunted, which creates some nasal asymmetry; and (3) the melolabial folds in the cheeks are asymmetric.

Interpositional Flaps

Interpositional flaps utilize two adjacent flaps that are both elevated and mobilized across each other in opposite directions. The **Z-plasty** is a typical interpositional flap

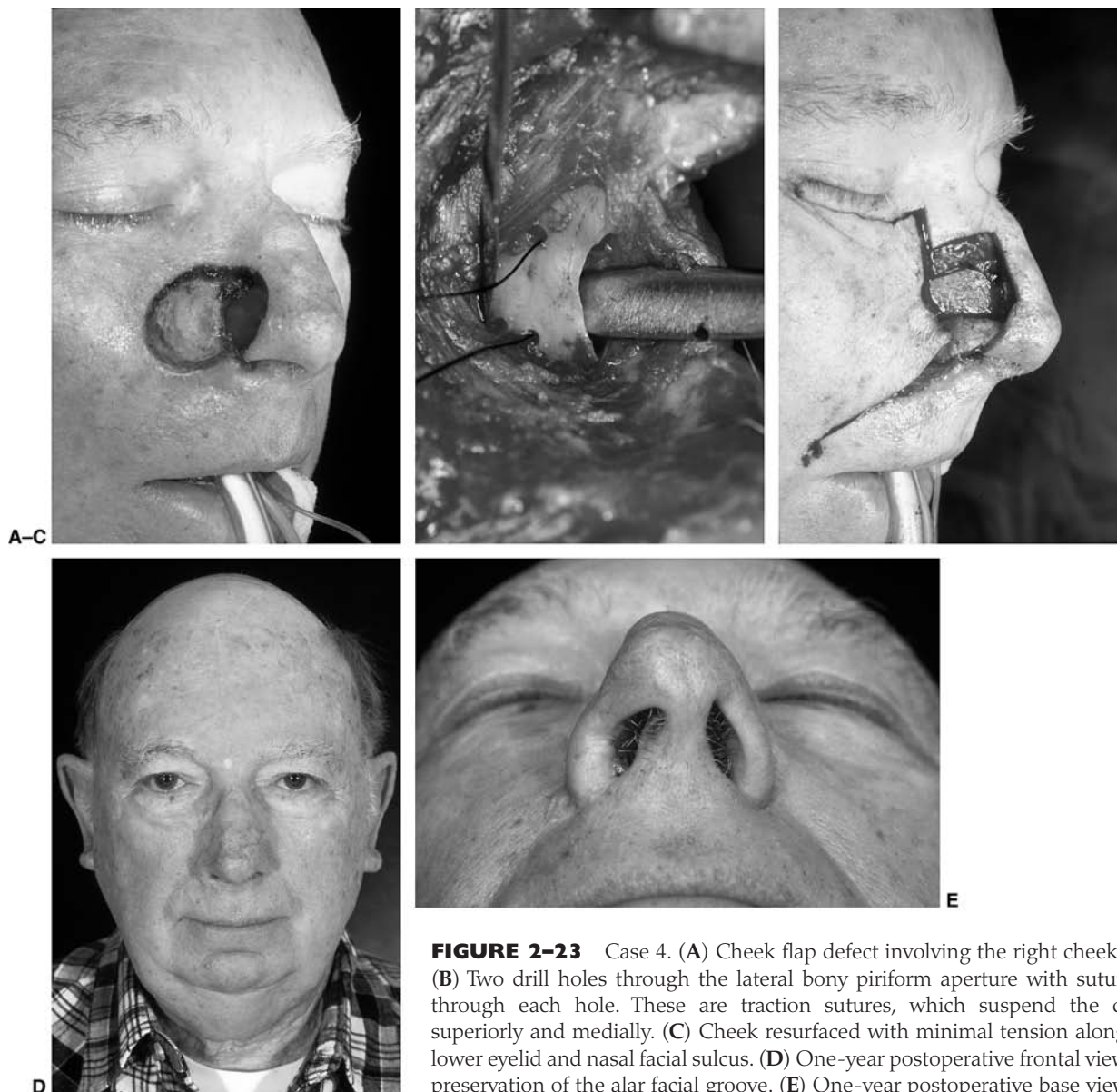


FIGURE 2-23 Case 4. (A) Cheek flap defect involving the right cheek and nose. (B) Two drill holes through the lateral bony piriform aperture with sutures passed through each hole. These are traction sutures, which suspend the cheek flap superiorly and medially. (C) Cheek resurfaced with minimal tension along the right lower eyelid and nasal facial sulcus. (D) One-year postoperative frontal view; note the preservation of the alar facial groove. (E) One-year postoperative base view.

that is versatile for defect repair as well as for scar revision. Each triangular flap is transposed over the other and the effect is a scar reorientation and elongation along the original axis. This interposition flap can be useful when a scar is oriented in an unfavorable direction, such as a vertical scar across the forehead. Similarly, the Z-plasty is effective when a scar needs lengthening through recruitment from surrounding tissues, such as a web deformity that might arise along the medial canthus. The angles of the Z-plasty flap dictate the degree of elongation of scar, i.e., 30-degree angles lengthen the scar by 25%, 45-degree angles lengthen by 50%, and a 60-degree flap elongates by 75%. The 60-degree flap creates a final scar reorientation exactly perpendicular to its original direction (Fig. 2-28). Multiple and compound

Z-plasties can be designed to address lengthy scars or larger cutaneous defects, respectively.⁶³

Interpolated Flaps

The *forehead flap* is a common interpolated flap for nasal reconstruction and has a rich history dating back to antiquity. The earliest nasal reconstructions were being done in India around 700 B.C. with large cheek flaps performed by potters and bricklayers, using cements, cotton sutures, leaves for templates, and ants' heads to approximate skin edges.⁶⁴ This art would be passed down in secrecy through family generations while little cross-cultural sharing would occur. The earliest documentation of using a forehead flap occurred in 1440 A.D. in India, later to be known as the "Indian method" of nasal

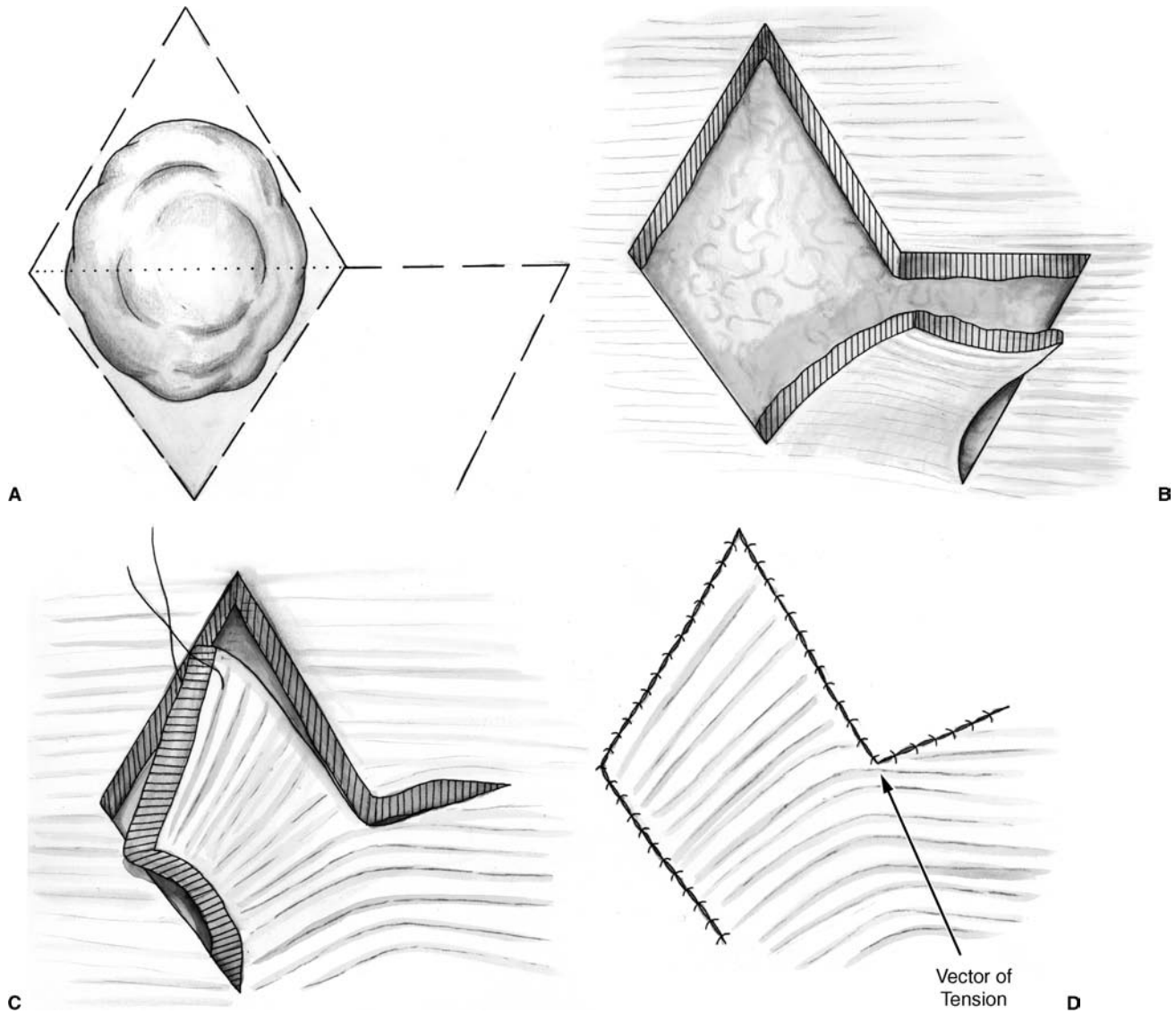


FIGURE 2-24 Limberg rhombic flap. (A) Flap design with 60- and 120-degree angles. (B) Flap elevated in the subcutaneous plane. (C) Transposition of the rhombic flap. (D) Resultant scar. Note the vector of tension is along one limb of the original defect.

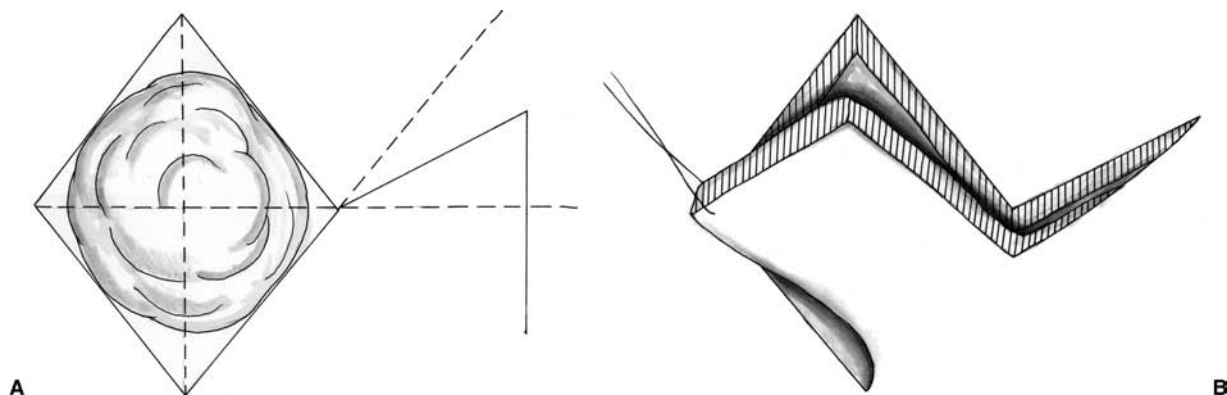


FIGURE 2-25 Dufourmentel modification of the rhombic flap. (A) Flap designed narrower and closer to the defect. (B) Transposition of flap.

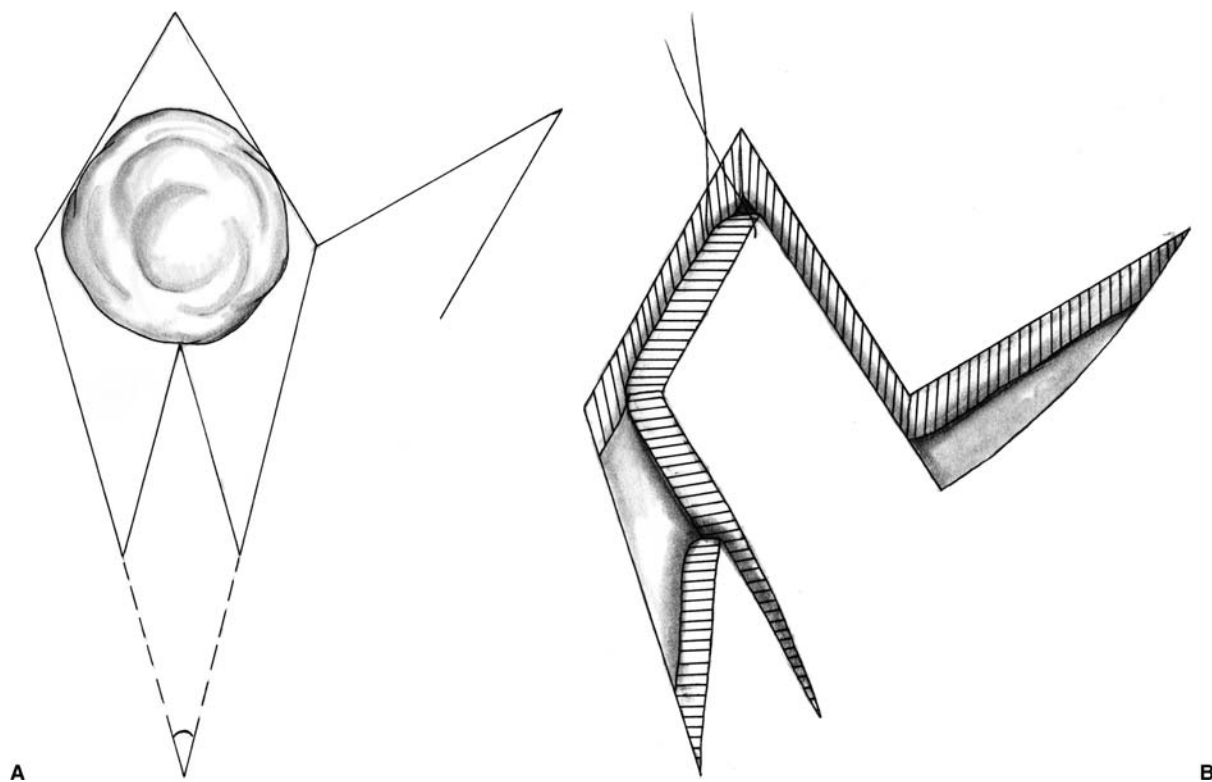


FIGURE 2-26 Webster 30-degree modification of the rhombic flap. (A) Flap designed with an M-plasty inferiorly to minimize tissue loss. (B) Flap transposed into the defect.

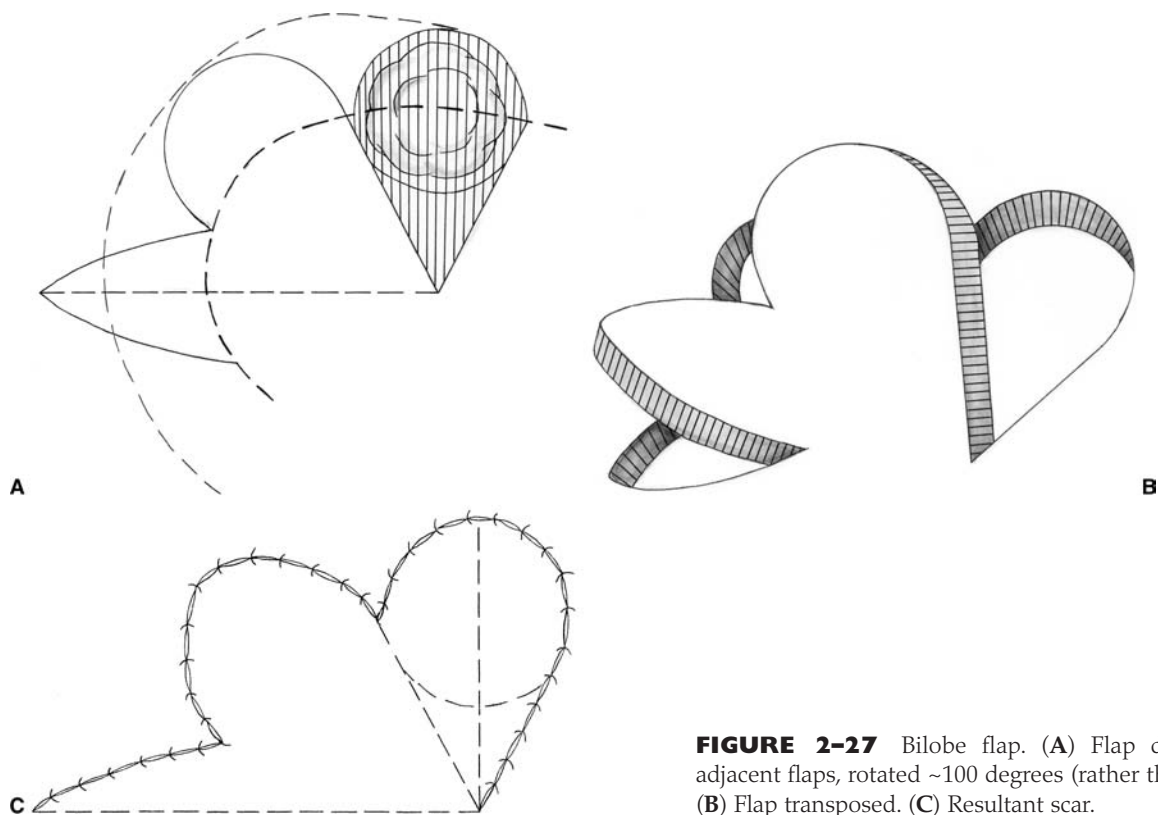


FIGURE 2-27 Bilobe flap. (A) Flap design with two adjacent flaps, rotated ~100 degrees (rather than 180 degrees). (B) Flap transposed. (C) Resultant scar.

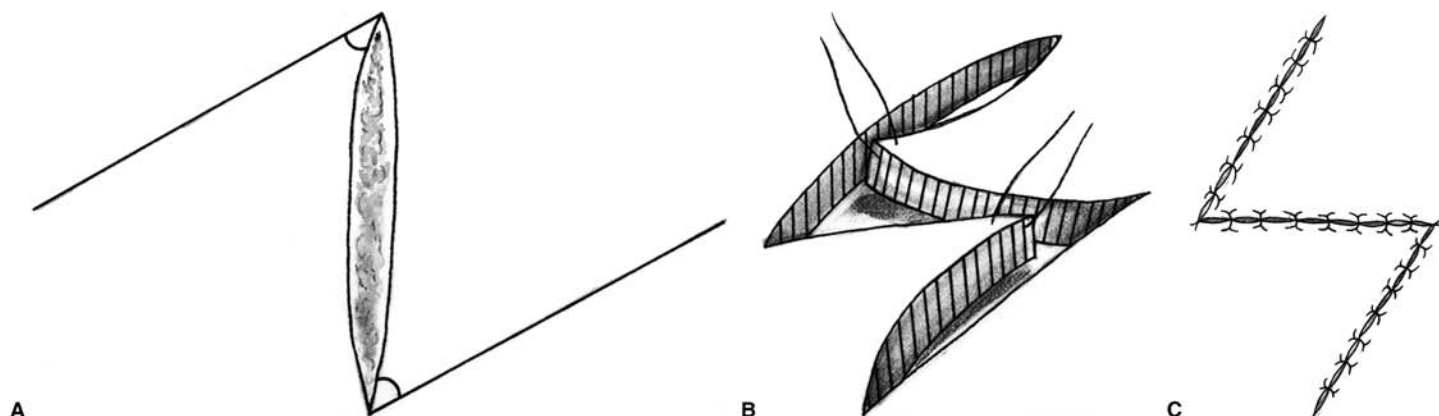


FIGURE 2-28 Z-plasty. (A) Flaps designed with central scar. (B) Each flap is transposed in opposing directions. (C) Resultant scar with central limb reoriented 90 degrees and original scar lengthened by 75% (with 60-degree flaps).

reconstruction.⁶⁵ As commerce expanded across continents, the first Western description of the forehead flap can be found in 1816 by a general surgeon named Joseph Carpue in an article entitled “An Account of Two Successful Operations for Restoring a Lost Nose from the Integuments of the Forehead.”⁶⁶ The 20th century brought significant advances in the forehead flap with a better understanding of flap dynamics, blood supply, and aesthetic units.

The contemporary forehead flap is an interpolated, regional flap based on a pedicle from the medial brow area. The forehead provides skin of excellent color and texture match to the nose with ample availability to resurface the entire nose, from ala to ala (usually ~6 cm).^{67–71} Precise flap design can be made from a template of the nasal defect and placed either paramedian or in the precise center of the forehead, the *paramedian* or *midline* forehead flap, respectively. Placing the skin paddle in the paramedian region centers it over the medial brow, capturing more of the supratrochlear artery and its branches.⁷² The midline skin paddle leaves a donor site scar in the exact middle of the forehead and may be somewhat less conspicuous than the paramedian one. Both designs create a dependable flap with acceptable scars. The plane of elevation is initially in the subcutaneous layer rather than subgaleal; the frontalis muscle need not be included with the skin paddle and only creates excessive bulk to the flap. The vasculature of the forehead skin runs vertically in the subcutaneous layer, allowing for a lengthy flap pedicle. The supratrochlear artery runs superficial to the corrugator muscle and perforates the orbicularis oculi muscle ~2 cm above the orbital rim, then runs vertically in the subcutaneous plane with extensive arborization. There is a robust collateral pattern in the medial canthal area between the supratrochlear artery and the angular artery off the facial artery. This rich arterial supply gives a strong perfusion pressure to the forehead flap, the primary factor

influencing flap viability. A pedicle based on the ipsilateral side of the defect allows greater inferior reach of the flap, whereas a contralateral pedicle has less rotation and torsion to the pedicle base as well as less visual obstruction to the patient. The pedicle can be narrowed to 1 cm at its base and extended into the brow itself, both of which improve flap mobilization.

The donor site within the forehead can usually be closed primarily after wide undermining. When some portions cannot be closed, healing by second-intention usually leaves the optimal result. Pedicle division is performed after a 3-week interval, during which time neovascularization occurs from the recipient bed into the distal flap (Fig. 2-29).

Including the galea and frontalis muscle with the primary forehead flap is advocated by some authors as an additional means of support, particularly in those individuals with small vessel disease, such as smokers.⁷³ This three-stage reconstruction uses an intermediate step to debulk the flap through lateral access, leaving the flap attached along the columella and pedicle. The pedicle is divided as a third stage, 6 weeks after initial flap transposition.

A single-stage forehead flap can be designed in select patients where the skin of the pedicle is carefully removed and the subcutaneous pedicle and island flap are tunneled under intact glabellar skin, permitting the skin paddle to fill the cutaneous nasal defect.⁷⁴ The procerus muscle can be excised following wide undermining in the glabellar region to minimize pressure on the subcutaneous pedicle. A small fullness can result from this pedicle that usually resolves over several months (Fig. 2-30). This flap is more tenuous and subject to significant congestion; it should be reserved for younger individuals without small-vessel disease. The advantages of avoiding the external pedicle and obviating the second procedure can be significant for some people, particularly those who need to return to work as soon as possible.



FIGURE 2-29 Case 5. (A) Forehead flap for a large nasal defect. (B) Nasal aesthetic subunits drawn, showing the nasal facial junction. (C) Aesthetic subunits completed with small advancement of the cheek up to the nasal facial groove. (D) Midline forehead flap designed with the skin paddle in the center of the forehead and the pedicle based on the right medial brow area. Note how the pedicle base becomes narrow and can extend below the level of the brow. (E) One-year postoperative oblique view. (F) Close-up view showing the camouflage of scars when placed along subunits.

The two-stage, interpolated *melolabial flap* is from the medial cheek and is useful for defects involving the distal third of the nose, including the columella.⁷⁵ The pedicle is superiorly based and consists primarily of subcutaneous tissue with the skin incision being more elliptical in shape. The distal skin paddle is thinned aggressively, much like the forehead flap, and is based on the random pattern vasculature in the subdermal layer. Pedicle division occurs after about 3 weeks, and the donor site can be managed by either replacing the skin pedicle back to the medial cheek or by excising it and

closing the cheek primarily (Fig. 2-31). The advantage of the latter is that only a single scar is left along the nasal-facial junction, as opposed to a second scar along the mid-cheek area that occurs when the pedicle is replaced. Wider flaps can leave some facial asymmetry when the donor site is closed primarily.

Tissue Expansion

Tissue expansion was first used in 1957 by Neumann⁷⁶ for auricular reconstruction by placing a balloon behind the ear. This was further popularized by Radovan^{77,78} for

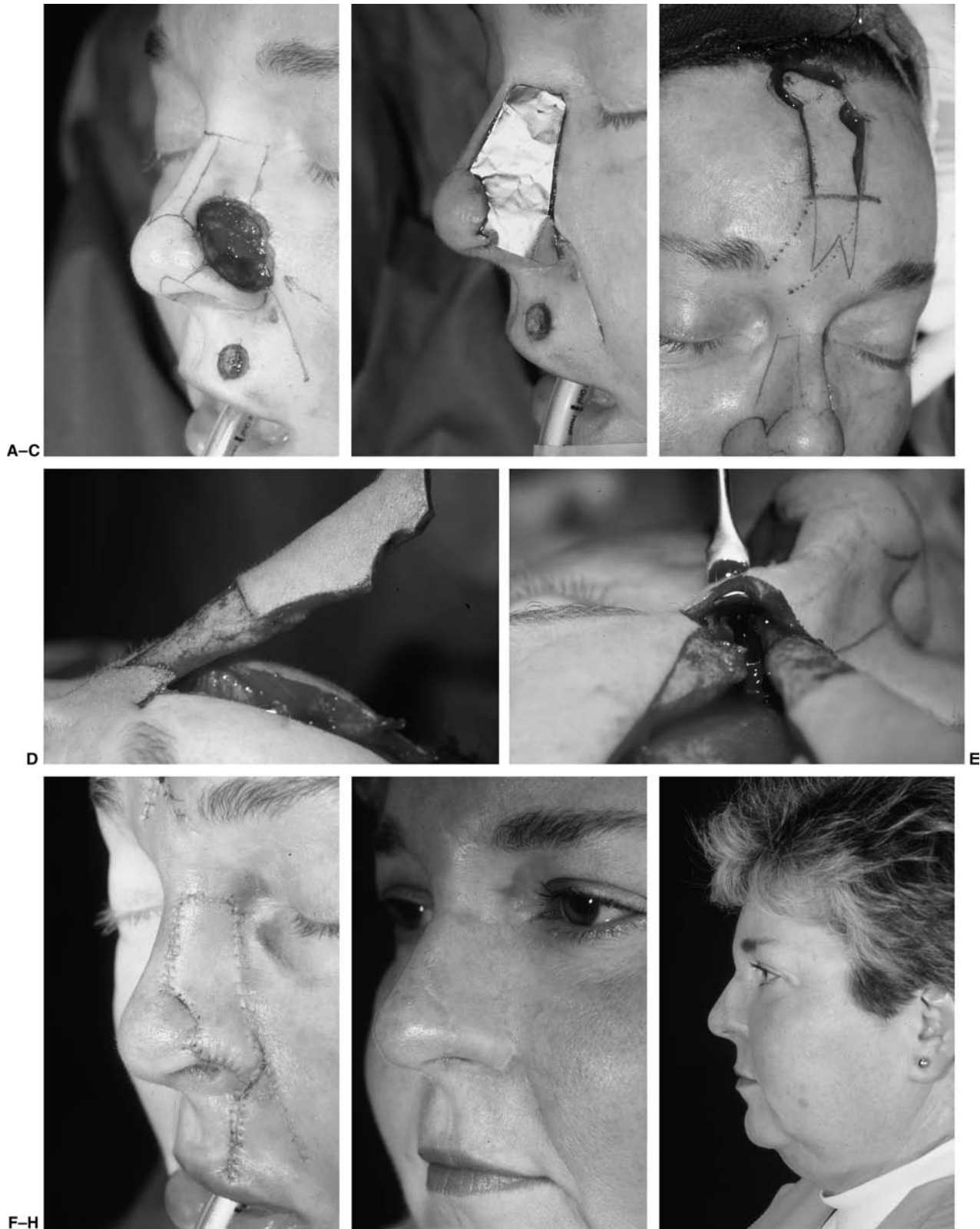


FIGURE 2-30 Case 6. (A) Single-stage forehead flap for a left nasal defect involving sidewall and ala. (B) Template created of the nasal defect after aesthetic subunits are completed. (C) Skin paddle elevated with anticipated subcutaneous pedicle and inferior cutaneous M-plasty. (D) Subcutaneous pedicle creating an island forehead flap. (E) Tunnel created under glabellar skin, connecting the forehead and nasal defect. (F) Forehead flap tunneled into the nasal defect for repair. (G) Six-month postoperative result with full flap viability. (H) Lateral view showing minimal fullness in the glabellar area.

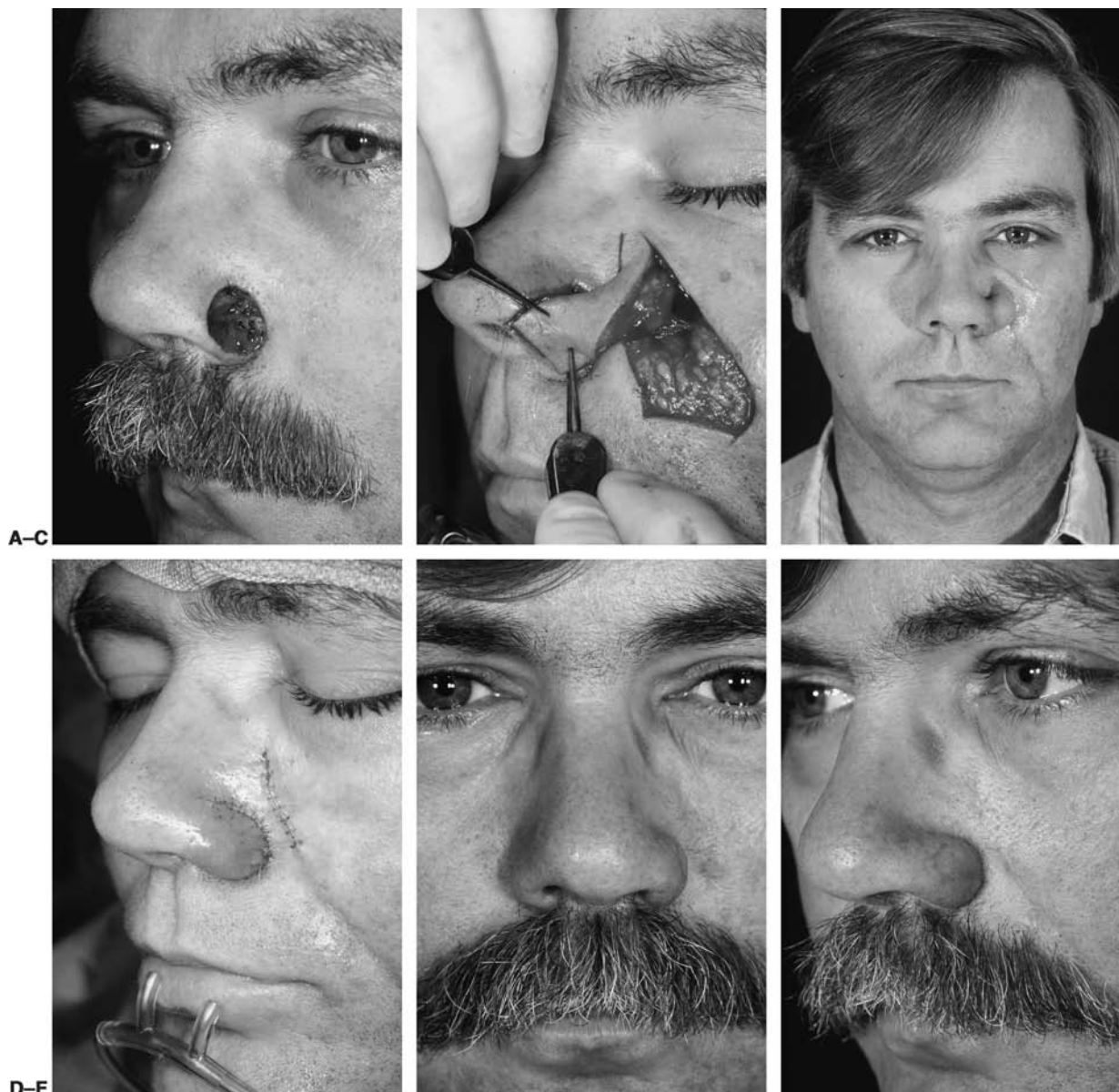


FIGURE 2-31 Case 7. (A) Melolabial flap for a left alar defect. (B) Flap design, elevation, and transposition of a left melolabial flap. The skin pedicle narrows, but the subcutaneous portion remains thick and robust. (C) Interpolated melolabial flap. (D) Following pedicle division and inset. (E) Six-month postoperative frontal view. (F) Six-month oblique view.

soft tissue reconstruction, especially for the breast. In the head and neck, tissue expansion is less frequently used but can be a useful tool with scalp reconstruction and scar revisions.^{79,80} There are inconveniences with expanders, such as duration of the procedure, temporary disfigurement, frequent follow-up visits to the physician, and some discomfort, but it continues to have a place in select circumstances. The rectangular balloon is the most efficient device in terms of the best volume-to-surface-area ratio.

Expansion occurs through a mechanism called *biologic creep* where metabolic and histologic changes occur in response to continued expansive pressure. *Mechanical*

creep refers to the temporary fragmentation and realignment of collagen fibers in the dermis that occurs during intraoperative tissue expansion.⁸¹ There are several important histologic changes that occur following tissue expansion.⁸² The epidermis remains roughly the same thickness, reflecting an increase in cellular activity in response to the pressure. During rapid expansion, the rete pegs may flatten some. The dermis actually thickens during expansion, the result of increased fibroblastic activity and collagen production. The collagen density and organization, however, are not improved, and there is a corresponding decrease in tensile strength. Melanin production is enhanced, giving a slightly pigmented tone

to expanded skin. Hair follicles remain constant, and thus the density is proportionally diminished and can leave expanded skin with some relative alopecia. Subcutaneous tissues do not tolerate expansion well and as much as 50% necrosis can be found. Cutaneous vasculature responds vigorously to expansion, and there is a proliferation in excess of skin growth. For this reason, expanded skin actually has an increased blood supply and is more robust than normal skin. Nerves, muscle, and bone all tolerate the expansion process well without significant physiologic loss. A fibrous capsule forms around the balloon and can be found as early as 7 days postexpansion. When left alone, it will continually resorb over the next 12 months.

Inserting the tissue expander requires some future planning in terms of the final flap design. The initial incision to insert the device is ideally in line with one of the final flap incisions and should never cross the body of the flap itself. The injection port may either be buried at an adjacent site for percutaneous inflation or left external for direct cannulization. Expansion usually begins 2 to 3 weeks following insertion and continues on a weekly or twice weekly schedule. One can palpate and inspect the overlying skin to assess the correct amount of injection, but it usually requires about 10 to 20% of the volume, and patient discomfort prevents overinjection. Intraoperatively, one final injection and expansion is usually performed prior to removing the implant. The

capsule is left in place as long as tissue volume is adequate for coverage. Excising the capsule tends to be a tedious maneuver but can slightly increase the extensibility to the flap without jeopardizing perfusion and viability.

UNIT DEFECTS

SCALP

Repair of scalp defects must consider the hairline as one of the immobile landmarks to avoid unnatural irregularities. Scalp incisions typically do not heal well and leave scars that are wider and more raised than those elsewhere on the face and neck. The scalp is characterized by its thick skin and the galea aponeurotica, both of which contribute to its lack of extensibility and is excellent perfusion. Most defects are repaired with *rotation flaps* that should be designed much larger than their counterparts elsewhere on the face; e.g., six times the ratio rather than four times the ratio for the peripheral arc. Furthermore, multiple peripheral flaps, designed in a spiral fashion, may be needed to resurface relatively small, central scalp defects.⁸³ The plane of elevation is in the avascular, subgaleal layer, immediately superficial to the periosteum. Careful reapproximation of the galea is critical to ensure strength of the closure and minimize alopecia along the incision (Fig. 2-32).

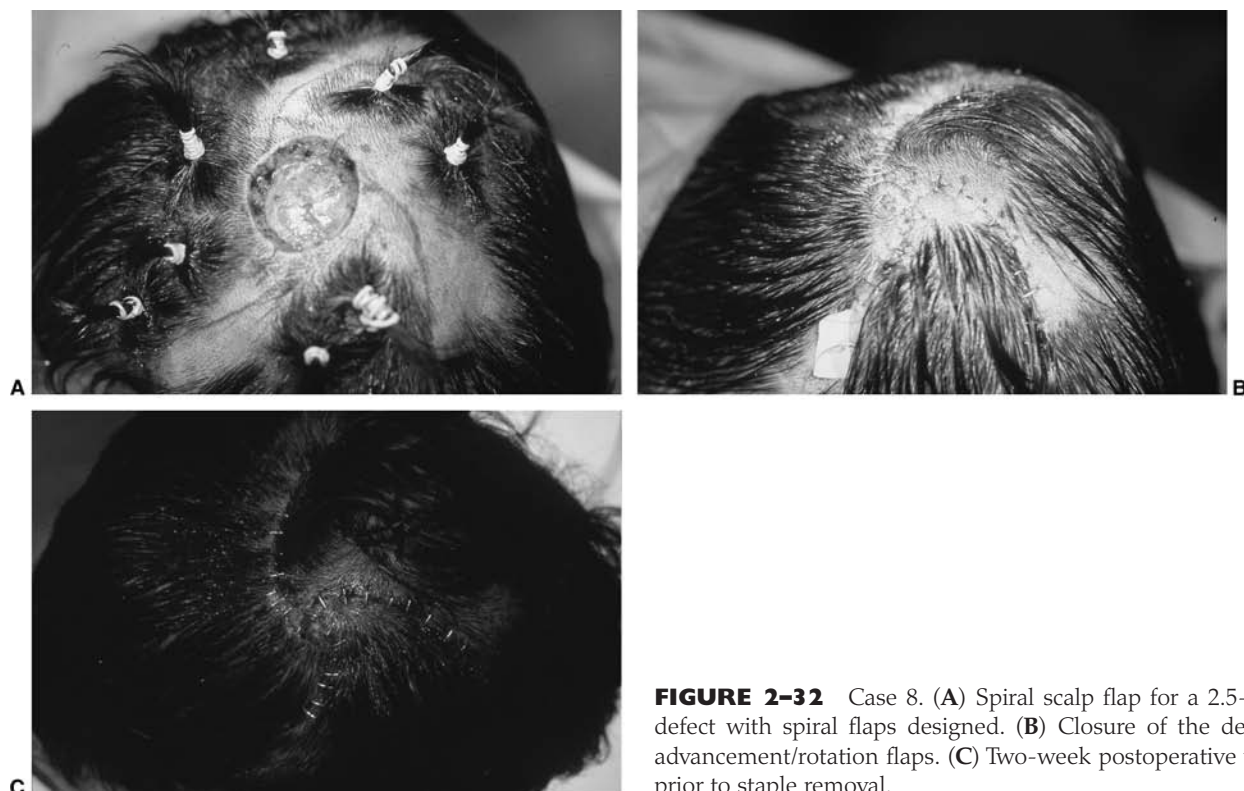


FIGURE 2-32 Case 8. (A) Spiral scalp flap for a 2.5-cm scalp defect with spiral flaps designed. (B) Closure of the defect with advancement/rotation flaps. (C) Two-week postoperative view, just prior to staple removal.

Tissue expansion is particularly useful for the management of scalp defects, again due to the unique lack of extensibility of the galea. Many large facial lesions, including congenital nevi, are better excised via serial excisions rather than subjecting the patient to the torment of tissue expansion. In the scalp, however, expansion may be the only option for resurfacing defects with hair-bearing tissue in relatively few surgical steps. A rectangular or crescent-shaped expander is often inserted, providing sufficient tissue volume for a large rotation flap (Fig. 2–33). As with any expansion, special consideration for the future flap design must be made prior to insertion of the expander. Most implants in the scalp can be overexpanded by at least 100%. With scalp reconstruction, the capsule around the expander is usually left behind to resorb spontaneously. On rare occasion, it may be necessary to excise portions of it to improve flap stretch. Other simpler methods of repair, such as skin grafts and second-intention healing, are seldom used due to the lack of hair with these techniques.

FOREHEAD

Forehead reconstruction must not distort the hairline above and laterally, and the eyebrows inferiorly. The supratrochlear and supraorbital neurovascular pedicles run vertically in the supragaleal plane and can be injured with horizontal incisions that extend to the periosteum. The temporal branch of the facial nerve is superficial and at greatest risk in the temporal area, especially over the zygomatic arch. Horizontal furrows are prominent in the forehead and represent distinct lines of minimal tension for concealing incisions and scars.

Most smaller flaps of the forehead recruit tissue from laterally and resemble advancement/rotation flaps. Subgaleal dissection creates flaps with greater perfusion but are less extensible and may jeopardize the supraorbital or supratrochlear nerves with a horizontal skin incision. Subcutaneous dissection is more tenuous but affords greater flap extensibility and remains superficial to the sensory and motor nerves of the forehead. Two commonly used techniques for smaller forehead defects include the bilateral advancement flaps and the O-T flaps because little vertical tension is created, minimizing distortion to the eyebrows and hairline. The horizontal limb can be placed along the anterior hairline and be well concealed. Both these methods still leave a vertical limb oriented perpendicular to the natural lines of the forehead, but that cannot be avoided (Fig. 2–34). O-Z flaps can orient the central scar in an oblique direction, but this rarely offers much more in terms of scar camouflage. Much larger cutaneous defects of the forehead are occasionally best managed with skin grafting, especially when the frontalis muscle remains and forehead contour is preserved (Fig. 2–35). Second-intention healing is another excellent option for larger forehead defects, including those that are full thickness. When located far above the brow line, this method can often leave the optimal aesthetic result, as seen with donor site defects following wide forehead flaps. When bare bone is exposed, one can drill the outer cortex and stimulate granulation tissue from the diploic space of the bone, thus expediting contracture and reepithelialization. Tissue expansion or serial excisions are alternatives that can be used in the forehead with some success.



FIGURE 2–33 Case 9. (A) Scalp reconstruction with rectangular tissue expander, prior to insertion. (B) Six-weeks postexpansion, immediately prior to the definitive reconstruction. (C) Scalp advancement/rotation flaps with closure of the scalp defect.



A-C

FIGURE 2-34 Case 10. (A) O-T flap for a circular defect of the right temple with flaps designed. (B) Resultant scar resembling the letter T. (C) Two-month postoperative result.



A

C



B

FIGURE 2-35 Case 11. (A) Full-thickness skin graft for a large, superficial, left forehead defect. (B) Following full-thickness skin graft with "pie crusts." (C) Nine-month postoperative view.

TABLE 2-4 CHEEK RECONSTRUCTION

Medial cheek	Cheek flap (advancement/rotation)
Lateral cheek	Facelift flap (advanced posteriorly)
Central cheek: small	Primary closure
	Rotation/advancement flap
	Transposition: rhombic
Central cheek: large	Cervical facial rotation flap

CHEEK

The cheek is surrounded by immobile structures such as the eyelids, nose, lips, and ears. The area for maximal tissue recruitment is from the lower lateral cheek, fortunately an area where there often exists significant laxity with jowl formation. The facial nerve and parotid duct are critical structures found in the cheek but they are in a plane immediately below the SMAS and deeper than most local flaps of this region. Facial lines of the cheek are well defined and can camouflage many scars. The borders of the aesthetic cheek unit are not always intuitive but must be kept in mind during flap design, especially the nasal-facial junction and the fact that it is higher on the nose than one thinks. The infraorbital line is flexible in that the incision can be placed along either the infraorbital rim or the subciliary crease. The latter may be better concealed but risks instability to the lower lid and subsequent retraction or ectropion, especially in the older patient population. The infraorbital incision has been criticized for creating chronic lymphedema to the lower lid. This appears to be more problematic during repair of facial fractures where the dissection is down to the bone; cheek flaps are only to the subcutaneous tissues and drainage from the lid is less of an issue.

Defects of the cheek can be divided into three different regions: lateral, central, and medial (Table 2-4). Defects posterior and lateral, around the ear, are often best repaired with wide undermining and posterior/superior advancement, much like a small facelift. Further support can be achieved through placcation of the SMAS layer on itself. A complete SMAS flap or deep plane elevation is rarely justified. The resultant scars are easily camouflaged around the ear, including the pretragal sulcus, and the degree of facial asymmetry usually remains subtle (despite the occasional request for a contralateral “facelift”) (Fig. 2-36). Small defects on the central cheek are often repaired with either a small advancement/rotation flap that orients scars along the RSTLs of the cheek, or a local transposition flap, such as the rhombic design. Recruitment is from lower cheek region, along the lines of maximal extensibility, and minimal tension is transferred to the lower lid (Fig. 2-37). Medial cheek defects, as well as large central ones, are ideally suited for a cheek advancement/rotation flap that leaves scars along the borders of the cheek aesthetic unit. Heavy cheek flaps should be suspended superiorly to the infraorbital rim (to avoid lower eyelid retraction) and to the periosteum of the medial pyriform buttress (to avoid blunting the nasal-facial groove). These suspension sutures are essential and can be used with a long-term resorbable suture material (see previous text) (Fig. 2-38).

PEARL... Cheek flaps should be suspended to the periosteum or bone itself through small burr holes. No tension should be transferred to the lateral nose or lower eyelid.



FIGURE 2-36 Case 12. (A) Cheek flap for a posterior/inferior cheek defect. (B) Nine-month postoperative view with camouflage of scars around the ear.



FIGURE 2-37 Case 13. (A) Rhombic flap for a 2.5-cm central cheek defect with modified rhombic flap designed. (B) Flap transposition and resultant scar. (C) Nine-month postoperative result.



FIGURE 2-38 Case 14. (A) Cheek flap for a 2.5-cm medial cheek defect with flap designed along the borders of the facial aesthetic units. (B) Six-month postoperative result. Melolabial fold remains full and can be revised.

Skin grafts are infrequently used except when aesthetic concerns are secondary, such as with the elderly or when surveillance for recurrence is at the forefront. Very large defects may require a graft with planned serial excisions over 2- to 3-month intervals. Wound contracture must be avoided because retraction of the lip, alae, or eyelid represents a multilayered effect that can be very difficult to correct secondarily.

NOSE

The nose is the most common site for cutaneous malignancies and nasal reconstruction. With its deep history, it

remains a fascinating area of facial plastic surgery. The analysis of a nasal defect must focus on a few key points: (1) Is there a violation of the internal lining? (2) Has the nasal skeleton itself been disrupted from the excision? (3) Is the defect over an area that is subject to collapse and airway obstruction (i.e., ala or lateral nasal wall)? (4) Which aesthetic subunits are involved? (5) Will excising the involved aesthetic units jeopardize the structural foundation? (6) How will vectors of tension from different flaps affect the alar rim, tip symmetry, and vestibular airway? The answers to these questions influence flap selection and emphasize the need for cartilaginous grafting.

Complex nasal defects are not necessarily larger in cross-sectional airway, but may be deep or positioned in a sensitive location such as the rim, soft tissue triangle, or alar-facial sulcus. Full-thickness defects of the nose must be viewed as a multilayered defect, and it is essential to repair each of the three layers independently and aggressively.

PEARL... Repair of full-thickness nasal defects should always address all three layers independently, i.e., internal lining, structural grafting, and resurfacing.

Small cutaneous defects are common but their reconstruction can be as challenging as larger ones, especially when searching for a quick and simpler flap in a patient with higher expectations.⁸⁴ Creating small degrees of nasal asymmetry or iatrogenic nasal obstruction are often viewed as significant new problems and should be avoided with every patient. Small (<5 mm) superficial defects often heal well through second-intention, especially those along the lateral wall or medial canthal areas. When close to the alar margin, even small degrees of

wound contracture easily distort the rim and may be conspicuous. Full-thickness skin grafting is often employed for superficial defects, including those of larger size when patients are not suitable surgical candidates. Their final outcome can be less predictable, particularly if wound contracture and collapse occur, but on occasion the result can be satisfactory. Small *alar rim* defects should be repaired with a two-layer composite graft from the ear, which provides sufficient rigidity to maintain alar contour and support. Securing the graft to the recipient bed is imperative and can be done with a bolster stitch through the graft (Fig. 2-39).

Most small defects of the nose (<1.5 cm) are repaired with a local transposition flap using adjacent nasal skin, such as the bilobe flap, rotation flap, bilateral advancement flaps, or **O-T** flap. An extremely useful method for repairing midline nasal defects, especially in individuals with a preexisting broad nose, is with wide undermining and bilateral advancement flaps. This is a relatively straightforward dissection in the supraprimerichondrial plane and leads to a result that may be more aesthetically pleasing and satisfactory than the original nose. This type of primary closure narrows the nose and creates a more



FIGURE 2-39 Case 15. (A) Composite graft for a superficial defect of the left alar lobule. (B) Composite graft from right ear to left nose. (C) Six-month postoperative result, oblique view. (D) Base view showing adequate support to the external nasal valve.

refined and slender look. Three technical points should be recognized: (1) The elliptical excision should be longer than typical designs to preserve a smooth dorsum; a short ellipse creates a relative depression in the area of the defect. (2) Traditional rhinoplasty maneuvers greatly facilitate closure, in particular the interdomal or transdomal stitch, which brings the lower lateral cartilages together, narrowing the tip and relieving tension on the repair. (3) A flaring stitch can be placed as a mattress stitch across both upper lateral cartilages prior to closure (Fig. 2-40). As the stitch is tightened, the dorsal septum

serves as a fulcrum and the upper lateral cartilages flare laterally, supporting the internal nasal valve during healing and wound contracture. The final result is a vertical midline scar that is well concealed despite being within the dorsal aesthetic unit (Fig. 2-41). Small defects involving other regions of the nose are often repaired with a bilobe flap, taking care to design it with the pedicle as dependent as possible and to camouflage the scars in the supra-alar crease or vertical borders of aesthetic subunits. Each lobe of the flap should be thinned aggressively to minimize the “pin-cushioning” effect.

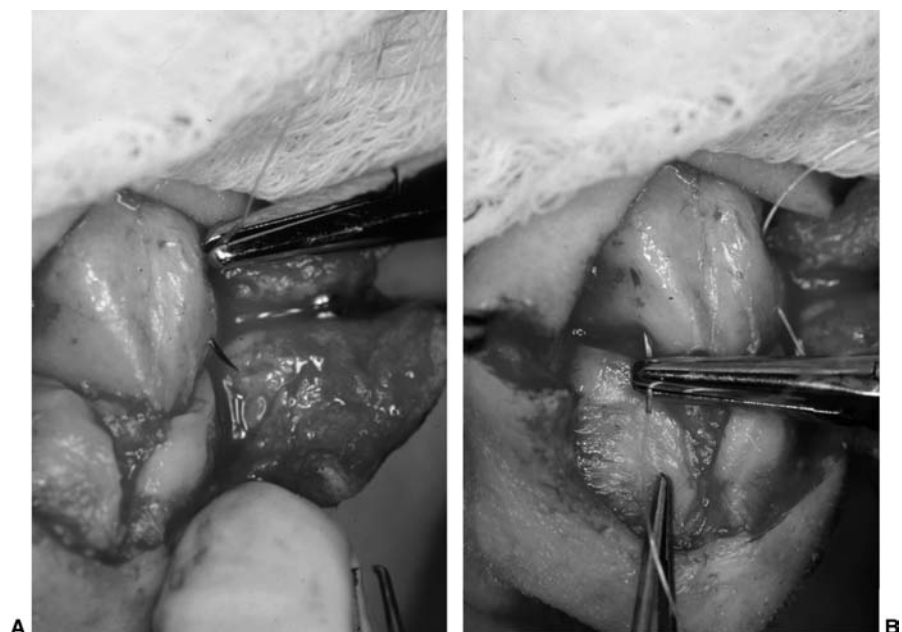


FIGURE 2-40 Flaring stitch to support the internal nasal valve. (A) Suture through the caudal/lateral aspect of the upper lateral cartilage. (B) Horizontal mattress stitch allows the dorsal septum to act as a fulcrum.



FIGURE 2-41 Case 16. (A) Bilateral advancement flap for a small central nasal defect in a preexisting broad nose. (B) Long elliptical excision in the midline. (C) Three-month postoperative result with some narrowing to the nose.



FIGURE 2-42 Case 17. (A) Bilobe flap for a 1-cm circular defect of the left alar lobule, with the bilobe flap designed. (B) Flap transposition showing the resultant scars. (C) Six-month postoperative result.

Wide undermining helps to distribute wound tension and create an even plane of scar. This exposure also allows easy placement of the flaring stitch. The transposition of even small cutaneous flaps along the nasal sidewall can pinch the external valve and quickly compromise the airway. Prophylactic structural grafting is warranted in many cases (Fig. 2-42).

It is imperative to respect the aesthetic border between the nose and cheek, especially along the alar/facial groove. Often the cheek is a tempting source for a local flap to the lateral nose, but a blunted sulcus will be created with an asymmetry that is quickly noticed. Even small defects located at the junction of the nose and cheek should be recognized as two distinct defects and repaired as such, i.e., cheek/lip defect with advancement/rotation flap, and nasal defect with its independent method of resurfacing (Fig. 2-43).

The *Reiger flap* is an advancement/rotation flap that slides glabellar and dorsal nasal skin inferiorly to resurface dorsal nasal defects. The donor site is closed primarily in a V-Y fashion. The blood supply is primarily from the medial canthal collaterals. The *single-stage forehead flap* can be used for defects of the dorsal or sidewall subunits. As discussed previously, this flap is similar to the traditional interpolated forehead flap except that the skin of the pedicle is removed and the flap and pedicle are passed under the intact glabellar skin. Passing this island forehead flap under a tunnel of skin obviates the need for a pedicle division, and the patient can often return to work much sooner than with a traditional flap. This single-stage forehead flap can be used for both small and large defects but should be reserved for individuals who are free of small-vessel disease.

The traditional, *interpolated forehead flap* remains the gold standard for resurfacing larger nasal defects for several reasons: (1) a large volume of skin is available to resurface the entire nose, (2) the color and texture match of the flap is excellent with native nasal skin, (3) vascular anatomy is robust and dependable, and (4) the donor site heals acceptably. Because a large volume of skin can be readily transferred, it allows one to apply the nasal aesthetic subunit principle aggressively and thus control defect shape and scar orientation. This leads to a long-term outcome that is aesthetic and reproducible. The *interpolated melolabial flap* is ideally suited for defects of the lower third of the nose, especially the alar lobule and columella. Its proximity to this area allows for a relatively simple flap with a short pedicle, as opposed to the forehead flap. Although the melolabial flap can be designed as a single-stage transposition to the lateral nose, it often creates a degree of blunting and fullness along this important sulcus. It is worthwhile to preserve the nasal/facial landmark and avoid crossing it with a single flap.

Structural grafting during nasal reconstruction serves two roles: (1) it prevents nasal sidewall collapse and obstruction, and (2) it resists wound contracture and cephalic retraction of the alar rim. New-onset nasal obstruction often is a significant problem for patients, irrespective of the aesthetic repair. There is a functional “danger zone” of the nose, corresponding to the inferior, lateral half of the nose, such that local flaps within this region create some degree of collapse and immediate nasal obstruction. This area corresponds to the supra-alar crease externally and the lateral border of the lateral crus internally. Preventing collapse of this region requires liberal use of cartilage grafting, even when native cartilage has not

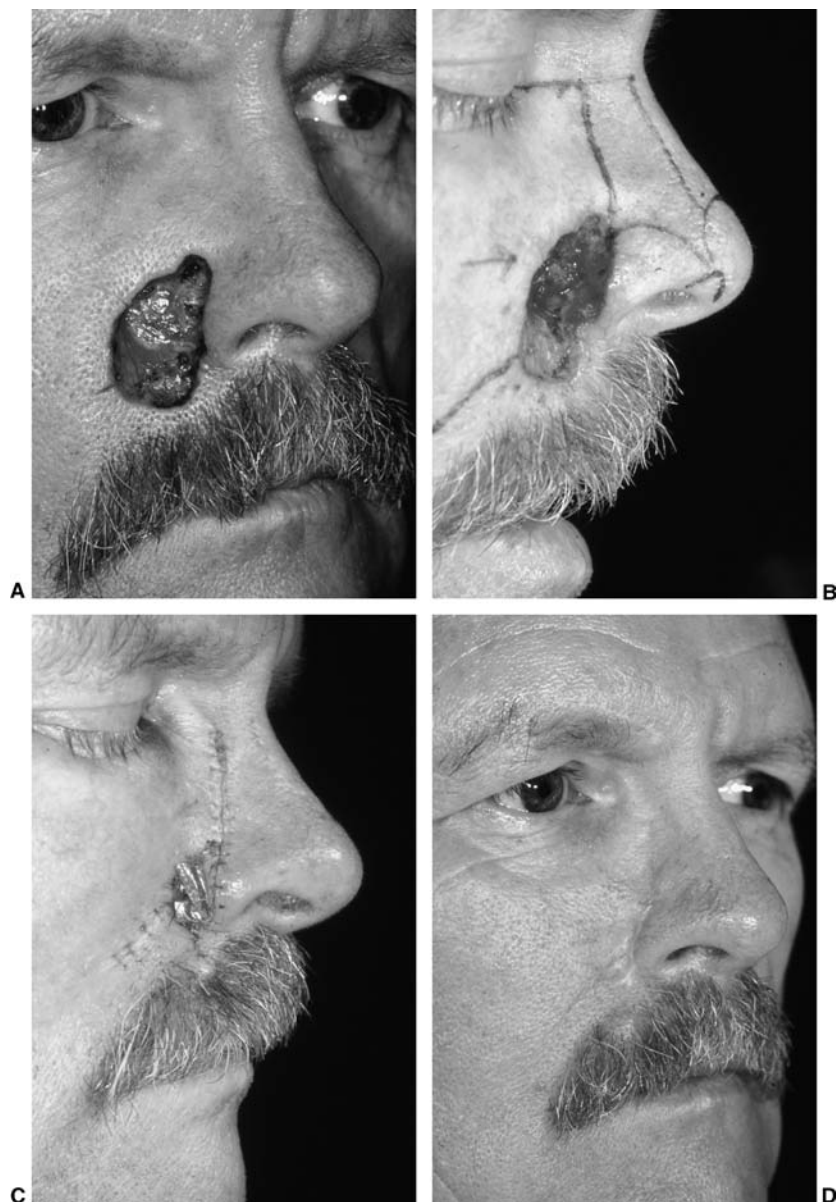


FIGURE 2-43 Case 18. (A) A 2.5-cm defect involving the right cheek and a small portion of the right alar lobule. (B) Aesthetic units defined, demonstrating a defect that involves multiple facial units. (C) Cheek advancement flap up to the nasal facial groove and a full-thickness skin graft to the lateral right alar lobule. (D) One-year postoperative view showing good distinction along the alar facial crease.

been excised. This form of “nonanatomic” cartilage grafting places batten grafts along the sidewall or alar lobule, often spanning from the bony pyriform aperture to the native cartilaginous structures. Septal cartilage is well suited for supporting the middle third of the nose, and conchal cartilage is ideal for the alar lobule and supra-alar crease.

PEARL... The supra-alar crease is a “danger zone” for local flaps where collapse and nasal obstruction develop quickly. Batten grafts should be placed liberally.

Cartilage grafts do not need to be especially thick but they should have sufficient length to rest on the bony pyriform aperture laterally. Short grafts may collapse intranasally and exacerbate airway problems. When repairing the alar lobule, it is imperative to support the caudal border of the alar lobule to resist its collapse and cephalic wound contracture with subsequent alar notching (Fig. 2-44). Failure to support the rim in this way allows it to pull up over time and presents a formidable challenge to repair later because it becomes a three-layered deformity. In addition to functional grafting, a nasal tip graft, more typically seen with cosmetic rhinoplasties, can be used with nasal reconstruction and improves the final aesthetics.



FIGURE 2-44 Case 19. Structural grafting of a nasal defect involving the tip and the right ala. (A) The alar lobule is at significant risk for collapse and notching. (B) Conchal cartilage graft secured in a *nonanatomic* location. (C) Forehead flap for resurfacing. (D) One-year postoperative result in an oblique view. (E) One-year base view demonstrating airway patency and alar support.

The *internal lining* defects must be diligently identified and meticulously repaired, regardless of their size. Larger defects require an independent flap or graft, and the surgeon should have experience working with several flaps and grafts because they each have specific advantages and indications. Smaller defects of the internal lining, particularly those involving the caudal border of the nose, can be repaired with composite grafts harvested from the ear. These grafts bring cartilaginous support with the lining, and this rigidity is essential when repairing the alar rim. For “cookie bite” defects involving the alar rim, a three-layer composite graft, harvested from the root of the helix, with skin on either side of the cartilage, is well suited (Fig. 2-45). The donor site can be closed with anterior undermining, although a small residual deformity may persist. For larger cutaneous defects where an external

resurfacing flap is also needed, a two-layer composite graft can be placed under the cutaneous flap, providing internal lining and support to the rim margin. These grafts are ideal along the alar rim as long as the external flap is sufficiently robust to support the graft. The conchal bowl is best suited for this type of graft because significant length is required, usually spanning the entire vertical height of the bowl. The donor site can usually be closed primarily, or, on occasion, with a skin graft.

Using local intranasal lining flaps for the repair of larger internal defects is ideal in that it replaces like tissue with like tissue, preserving a physiologic mucosa while avoiding excess bulk or desquamation. Mucosa can be mobilized off the inferior turbinate, nasal septum, or upper lateral nose. The inferior turbinate flap is based anteriorly and best mobilized by delivering the entire

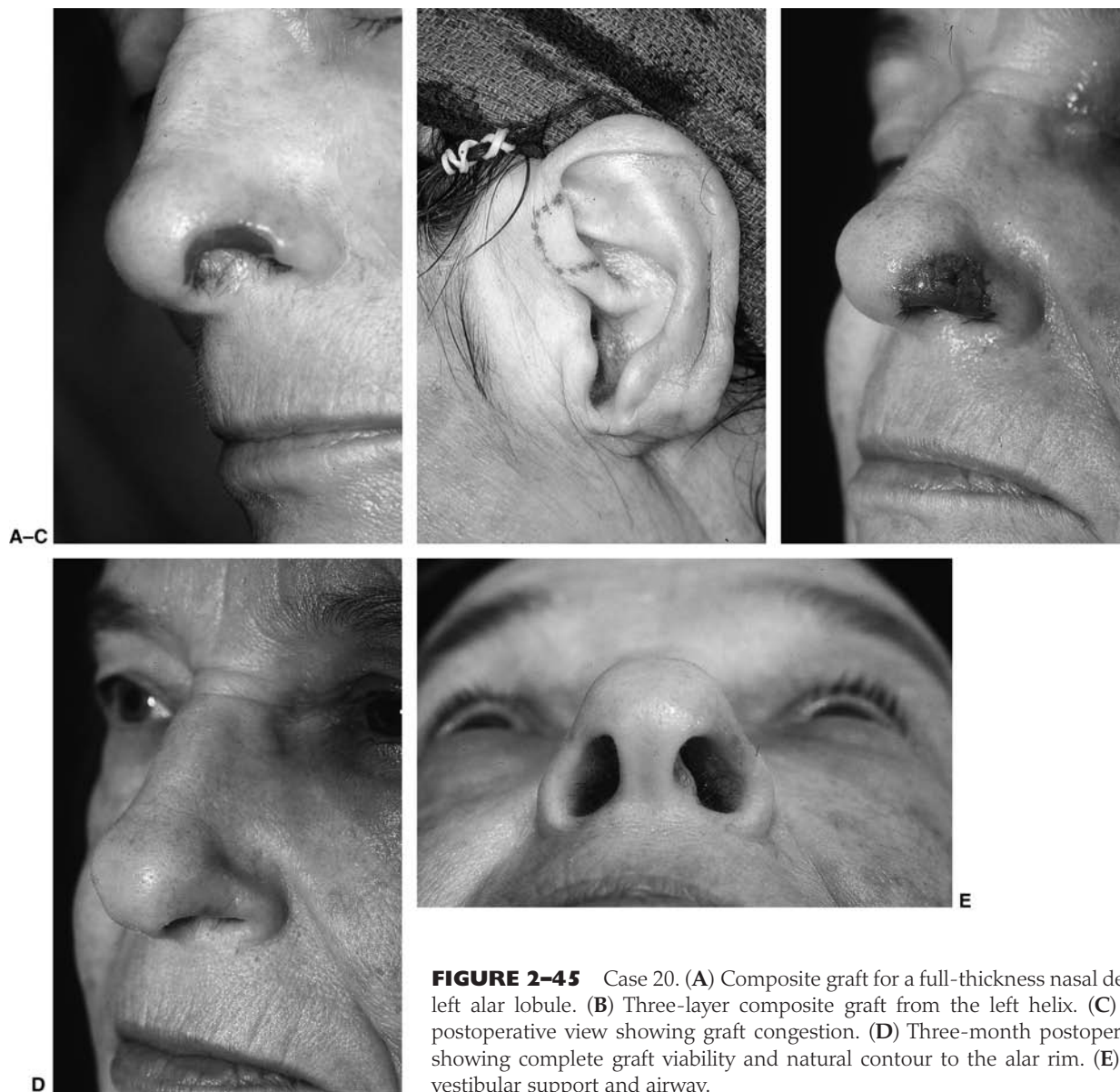


FIGURE 2-45 Case 20. (A) Composite graft for a full-thickness nasal defect of the left alar lobule. (B) Three-layer composite graft from the left helix. (C) Five days postoperative view showing graft congestion. (D) Three-month postoperative view showing complete graft viability and natural contour to the alar rim. (E) Sufficient vestibular support and airway.

turbinate extranasally and then removing the conchal bone. The ipsilateral septal mucosal flap is based anteroinferiorly, off the septal branch of the superior labial artery. The pedicle is robust enough to support the entire septal mucosa, including the mucosa off the posterior septum. Great care should be taken to elevate the flap in the subperichondrial plane and avoid inadvertent perforations (Fig. 2-46). Mucosa from the lateral nasal wall can be elevated and mobilized inferiorly as a bipediced flap. These flaps are ideally suited for defects of the alar lobule. Contralateral septal mucosa can be swung over to the internal lining defect when brought with a portion of septal cartilage. In this way, this “hinged composite flap” will repair the structural and lining deficit with a single flap.

External nasal skin can be used as an epithelial “turn-in” flap for intranasal defects of the lower half of the nose. This is a cutaneous flap from the upper nose that is elevated from superior to inferior, being based on an inferior subcutaneous pedicle. The flap is then flipped over and turned in to face intranasally (Fig. 2-47). The epithelial turn-in flap has the advantage of utilizing skin that might otherwise be discarded when applying the aesthetic subunit principle to the resurfacing. The disadvantage is that it buries external skin that is at risk for developing a cutaneous malignancy. Concerns with flap bulk and desquamation have not been borne out.⁸⁵

The distal end of the resurfacing flap, either a melo-labial or forehead flap, can also be wrapped around itself and provide epithelium for the internal nose. This portion



FIGURE 2-46 Case 21. (A) Septal mucosa flap for a subtotal nasal defect with an extensive internal lining deficit. (B) Bilateral septal mucosal flaps elevated and mobilized. (C) Left septal mucosal flap positioned for internal lining. (D) Base view following structural grafting and forehead flap. (E) Two-year postoperative frontal view. (F) Two-year oblique view.

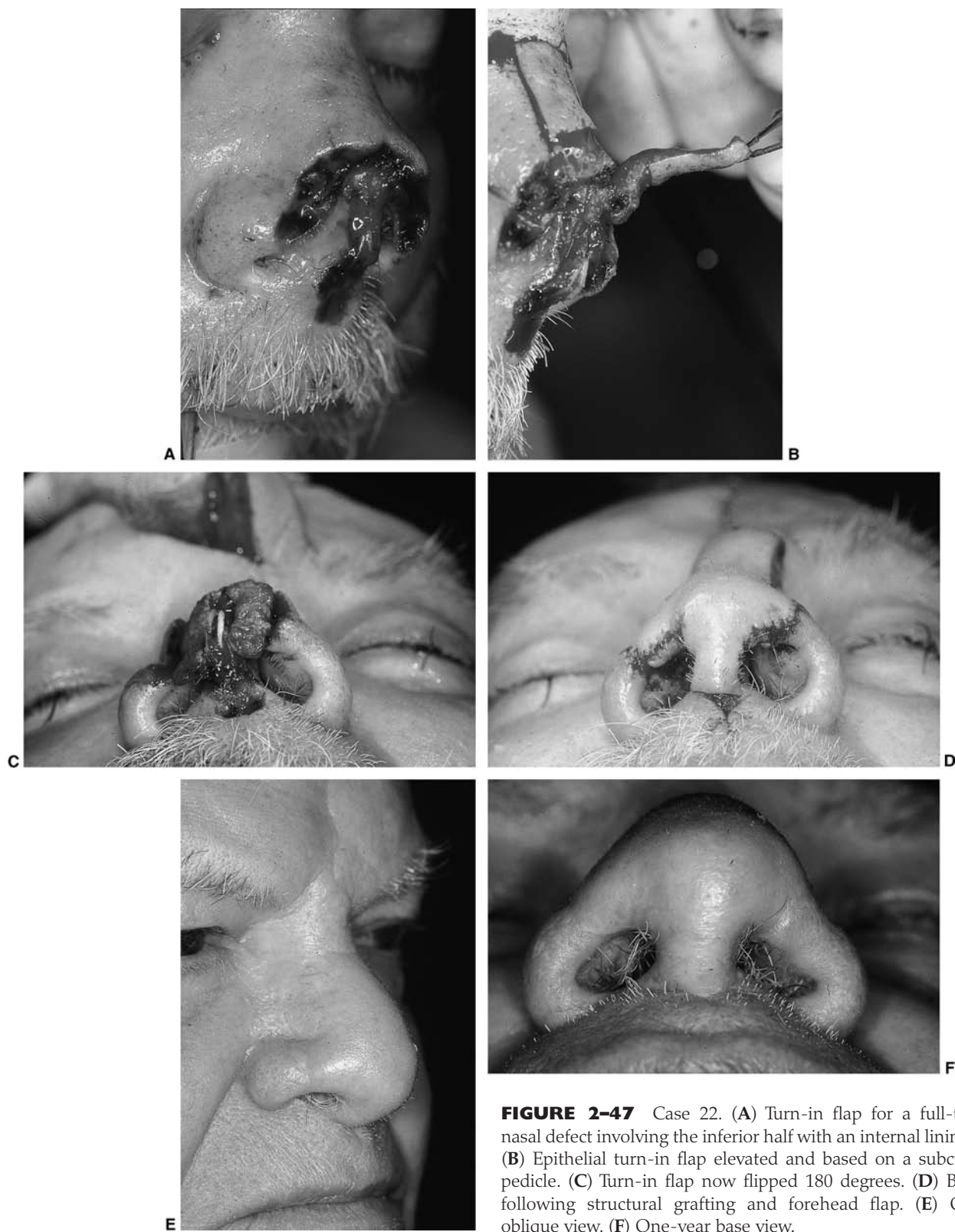


FIGURE 2-47 Case 22. (A) Turn-in flap for a full-thickness nasal defect involving the inferior half with an internal lining deficit. (B) Epithelial turn-in flap elevated and based on a subcutaneous pedicle. (C) Turn-in flap now flipped 180 degrees. (D) Base view following structural grafting and forehead flap. (E) One-year oblique view. (F) One-year base view.

of the flap should be thinned aggressively and may still require future adjunct procedures to improve the airway or to refine the thickened alar rim. A second epithelial flap can also be brought in to provide internal lining coverage.

This usually represents a last resort when a significant portion of the native nose has been resected. A pericranial flap from the forehead can be hinged inferiorly and draped into the nose as a vascularized, thin flap for

internal lining. Although there is no epithelium to this flap, rapid mucosalization often occurs from within the nose. This is similarly reserved for major nasal defects where intranasal flaps are no longer available.

LIP

Lip defects are found in a variety of sizes and shapes and require a broad armamentarium of surgical options (Table 2–5). Function is of paramount consideration and occurs in two forms. First, maintaining lip height is essential for oral continence and is a function of muscular continuity and reapproximation. Second, the lips

TABLE 2–5 LIP RECONSTRUCTION ALGORITHM

Mucosa only	Mucosal advancement Conversion to wedge with primary closure
Less than one third	Wedge, with possible W -plasty at mental crease
One third to two thirds	Karapandzic Estlander Abbe (if commissure uninvolved) Gillies fan flap
Greater than two thirds	Bernard-Burrow-Webster microvascular flap

should have sufficient laxity to allow an adequate oral aperture for using a spoon and possibly inserting dentures. Aesthetically, the free lip border is subject to notching during wound contracture and must be considered when designing local flaps. Precise alignment of the vermillion border is an important surgical step with all perioral surgery, and its misalignment is readily conspicuous.

Cutaneous defects of the upper lip can be particularly challenging due to the number of “immobile landmarks” in the area. Specifically, the lip border, columella, ala, melolabial fold, and philtrum are all important structures that must not be distorted during flap design. Tension vectors and resultant scars must be anticipated to preserve symmetry in this area. Advancement and small rotation flaps from the medial cheek area can be used for many small cutaneous defects of the lateral lip (Fig. 2–48). Skin grafts are also widely employed when the defect is superficial. Narrow defects confined to the vermillion can be repaired with mucosal advancement flaps from the labial surface. This method should be used judiciously because overly aggressive flaps result in a thin lip that is often retracted or notched, and occasionally creates oral incontinence. As the size of the cutaneous defect enlarges, it is often necessary to convert it to a full-thickness defect and repair it accordingly, allowing muscle-to-muscle apposition and preservation of vertical lip height.

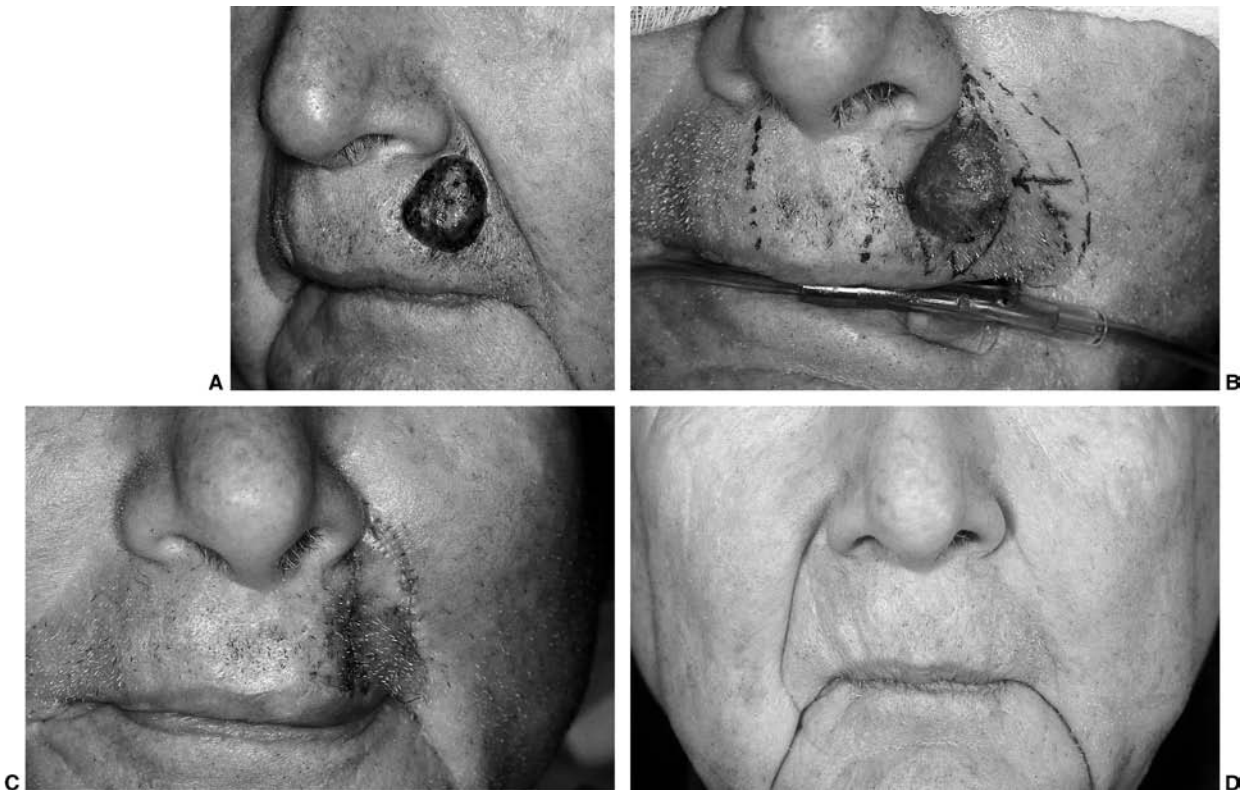


FIGURE 2–48 Case 23. (A) A 2-cm left upper lip cutaneous defect. (B) Advancement/rotation flap designed with critical landmarks identified. (C) Resultant scars following flap transfer. (D) Six-month postoperative view.

Lip defects up to one-third the width can usually be repaired with some form of bilateral mucosal-cutaneous advancement flaps, be it a primary wedge, **W**-plasty, or with small modifications around the nasal base or mental crease. With these flaps, essential elements include a three-layer repair, with specific attention to the muscular layer, precise vermilion border alignment, and avoiding scars across the mental crease.

Defects between one and two thirds may require a lip switch flap that recruits tissue from the contralateral side, based on the labial artery. When the oral commissure is involved with the defect, the rotating flap is referred to as the "Estlander" flap and usually requires a future revision to the oral commissure (Fig. 2-49). When the oral commissure is not involved, the flap is referred to as an "Abbe" flap and is an interpolated flap based on the contralateral labial artery, i.e., a left Abbe flap is based on the right labial artery. The width of the interpolated flap is one-half the width of the primary defect, thus equalizing the upper and lower lips. The design mandates a second-

stage pedicle division, usually performed after a 3-week interval (Fig. 2-50). Both flaps bring muscular bulk to the involved lip, but that portion is nonfunctional, that is, the muscular fibers are denervated and it remains a static segment of lip. The Karapandzic flap is used for similar size defects but has the advantage of recruiting muscular tissue without sacrificing neural function. The flap design is along the melolabial fold and the plane of dissection is through the orbicularis muscle, bluntly dissecting between fibers, down to, but not through, the oral mucosa. The dissection preserves neural fibers innervating the orbicularis muscle and thus maintains oral function and continence. Neural fibers are oriented radially with the muscular fibers and can be seen coming from the undersurface during blunt muscular dissection (Fig. 2-51). The limitation of these flap designs is microstomia, particularly with individuals using dentures (Fig. 2-52).

Defects in excess of two thirds of the lip often require a reconstruction that brings tissues from outside the

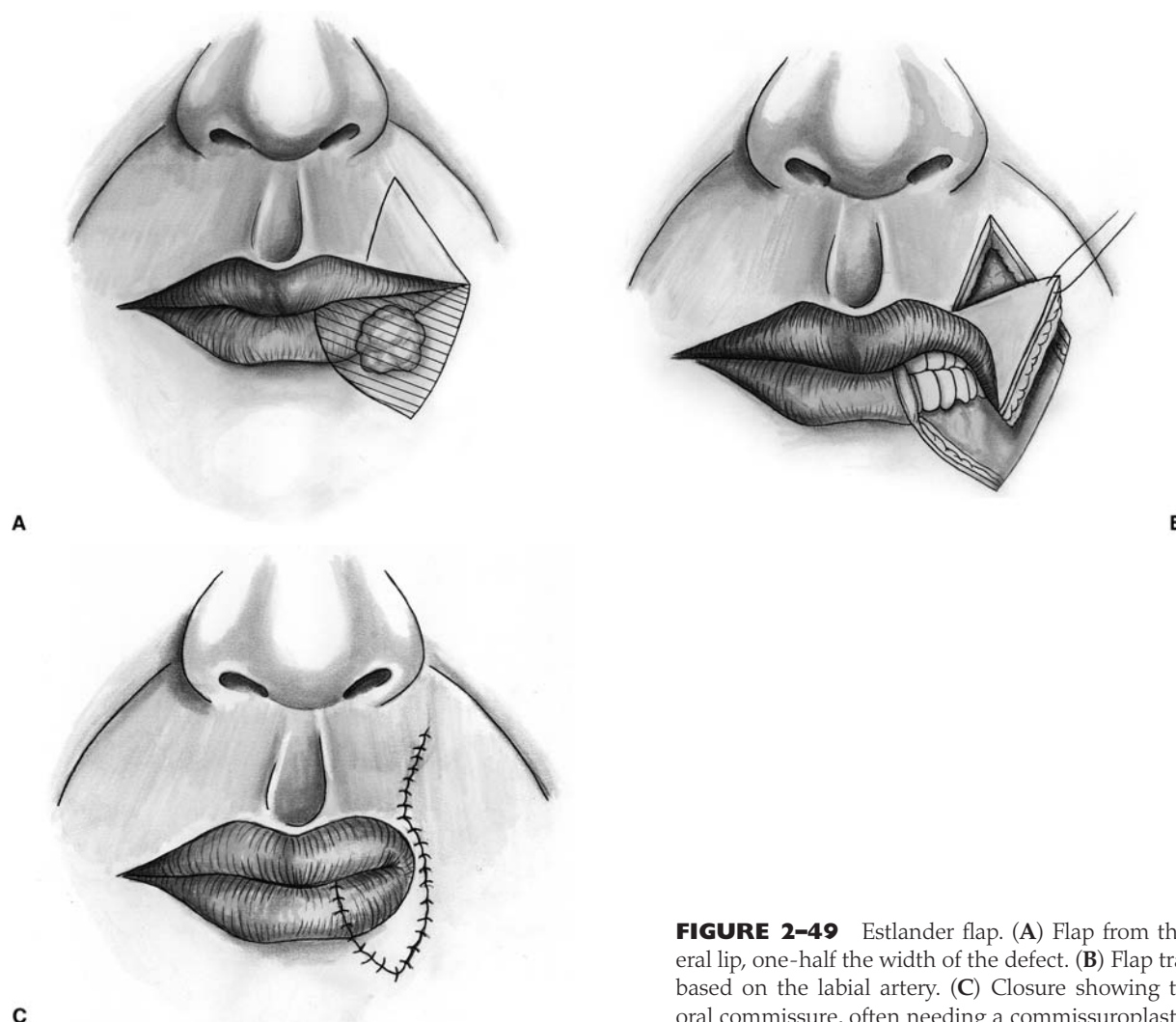


FIGURE 2-49 Estlander flap. (A) Flap from the contralateral lip, one-half the width of the defect. (B) Flap transposition, based on the labial artery. (C) Closure showing the rounded oral commissure, often needing a commissuroplasty.

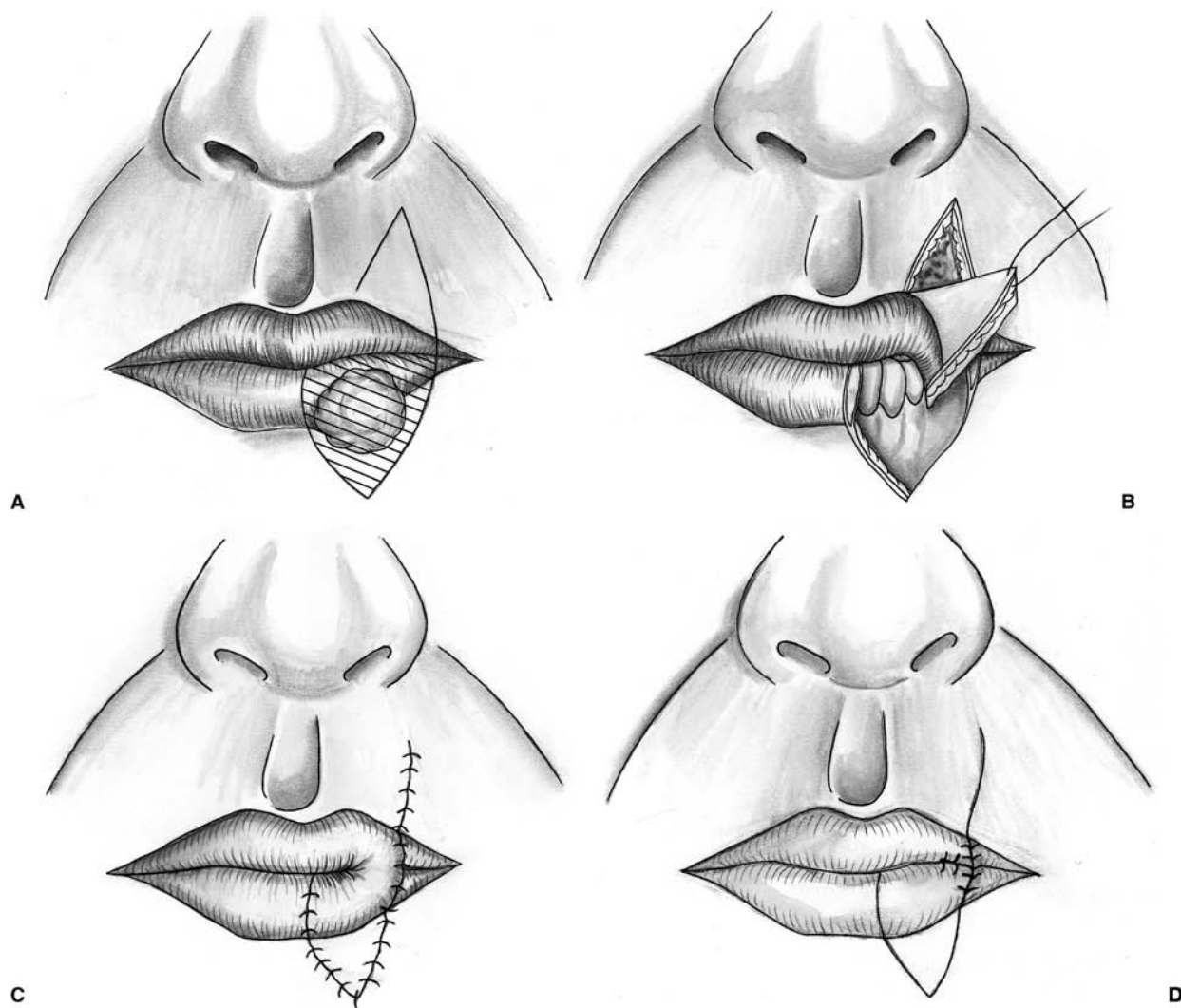


FIGURE 2-50 Abbe flap. (A) Lip defect preserving the commissure, with flap design from the upper lip. (B) Flap transposition. (C) Interpolated flap with the pedicle crossing the mouth. (D) Lip scars following pedicle division.

perioral area. The Bernard-Burrow-Webster flap for major lip reconstruction uses cheek skin, subcutaneous bulk, and the buccal mucosa for lip repair. Bilateral cheek advancement flaps are designed to be mobilized medially, incorporating an excess rim of buccal mucosa that folds anteriorly to serve as the new vermilion. The donor site intraorally is closed primarily. Care is used during the dissection to avoid injury to Stensen's duct (Fig. 2-53).

EYELID

The eyelid and lips share several common features in terms of aesthetics and function. It is imperative to realign the aesthetic landmarks of the gray line in the eyelid and the vermilion border in the lip. Similarly, the essential functional consideration is maintaining vertical height and tone as the free border can easily distort and

retract. Although it is often tempting to close small circular defects in a vertical fashion, particularly because they leave scars oriented in a favorable direction, vertical traction forces must be avoided because retraction, notching, and ectropion can quickly arise. Tension vectors should be oriented in a horizontal direction whenever possible, even at the expense of scars and natural skin creases. Consequently, most small defects of the lid are closed with horizontal flaps, or possibly in an O-T fashion, to ensure the preservation of lid height. This is especially true with lower lid defects where retraction is more problematic. On occasion, there may be significant dermatochalasis of the upper lid, allowing one to orient the closure horizontally, within the supratarsal crease. Fine silk sutures are often used around the eye (and mouth) because they are significantly softer than nylon and are less likely to irritate the cornea.

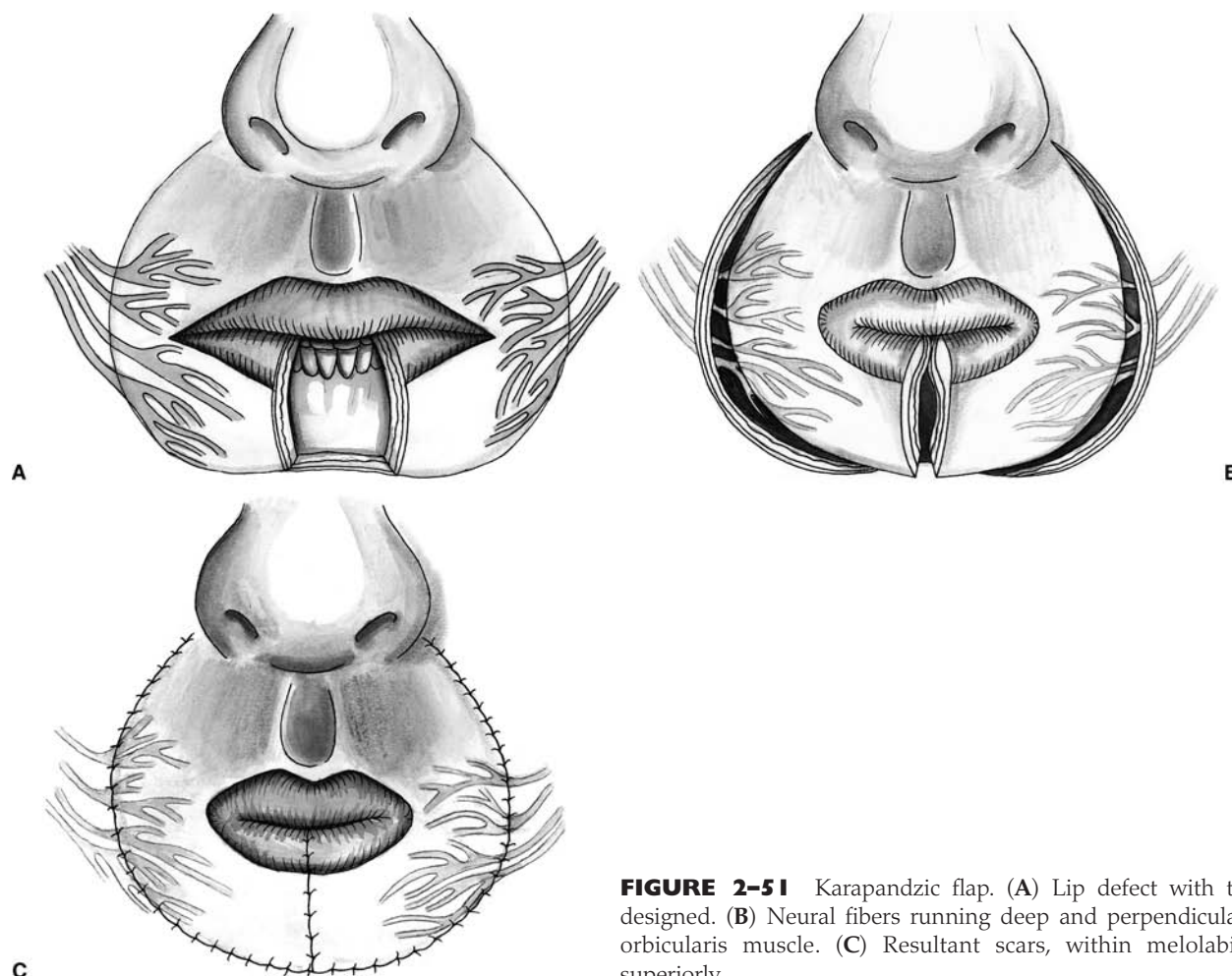


FIGURE 2-51 Karapandzic flap. (A) Lip defect with the flaps designed. (B) Neural fibers running deep and perpendicular to the orbicularis muscle. (C) Resultant scars, within melolabial folds superiorly.

The direct wedge excision is modified to a pentagonal shape, allowing the vertical edges of the tarsal plate to approximate in a parallel fashion. The gray line of the lid is between the lash line and row of meibomian glands, and should be meticulously aligned (Fig. 2-54). The conjunctival surface need not be sutured when the tarsal plate and orbicularis have been reapproximated. Sutures in this area can risk corneal irritation, and all knots should be buried away from the eye. Skin grafts from one lid to the other can be a useful tool with large, superficial defects and when sufficient dermatochalasis exists. All skin grafts contract some, and it is occasionally necessary to place a “Frost stitch” to help support the lower lid during the acute healing phase. This stitch is through the gray line of the lower lid and is secured to the deep tissues of the eyebrow, giving superior support to the lower lid. Although it is a nuisance for the patient, it can be an important adjunct to the reconstruction in preventing lower lid retraction or ectropion. It is important to assess the preexisting lid tone because many elderly individuals have such laxity that ectropion becomes inevitable

without a formal shortening procedure. A pentagonal excision of the lower lid can accomplish this easily, centering it at the lateral limbus and re-approximating the tarsus and gray line accurately. A “tarsal strip” procedure is a more effective way of both shortening the lid and resuspending the lateral canthus in a lateral, superior, and posterior direction. The lateral strip of tarsus is anchored to *Whitnall’s tubercle*, just inside the lateral orbital rim.⁸⁶

Larger and more complex eyelid defects may involve the orbicularis muscle, tarsal plate, lacrimal system, or conjunctiva. One can categorize the eyelid defect into those limited to the anterior lamella, i.e., skin and orbicularis muscle, and those involving the posterior lamella, i.e., the tarsus and conjunctiva. The repair of composite defects must address the rigidity of the lid through a hard palate graft or a composite cartilage graft from the contralateral eye, ear, or septum.⁸⁷ Cartilage from the triangular fossa of the ear is ideally shaped for tarsus reconstruction and leaves minimal donor site morbidity. Periosteum from the lateral orbital rim can also serve to

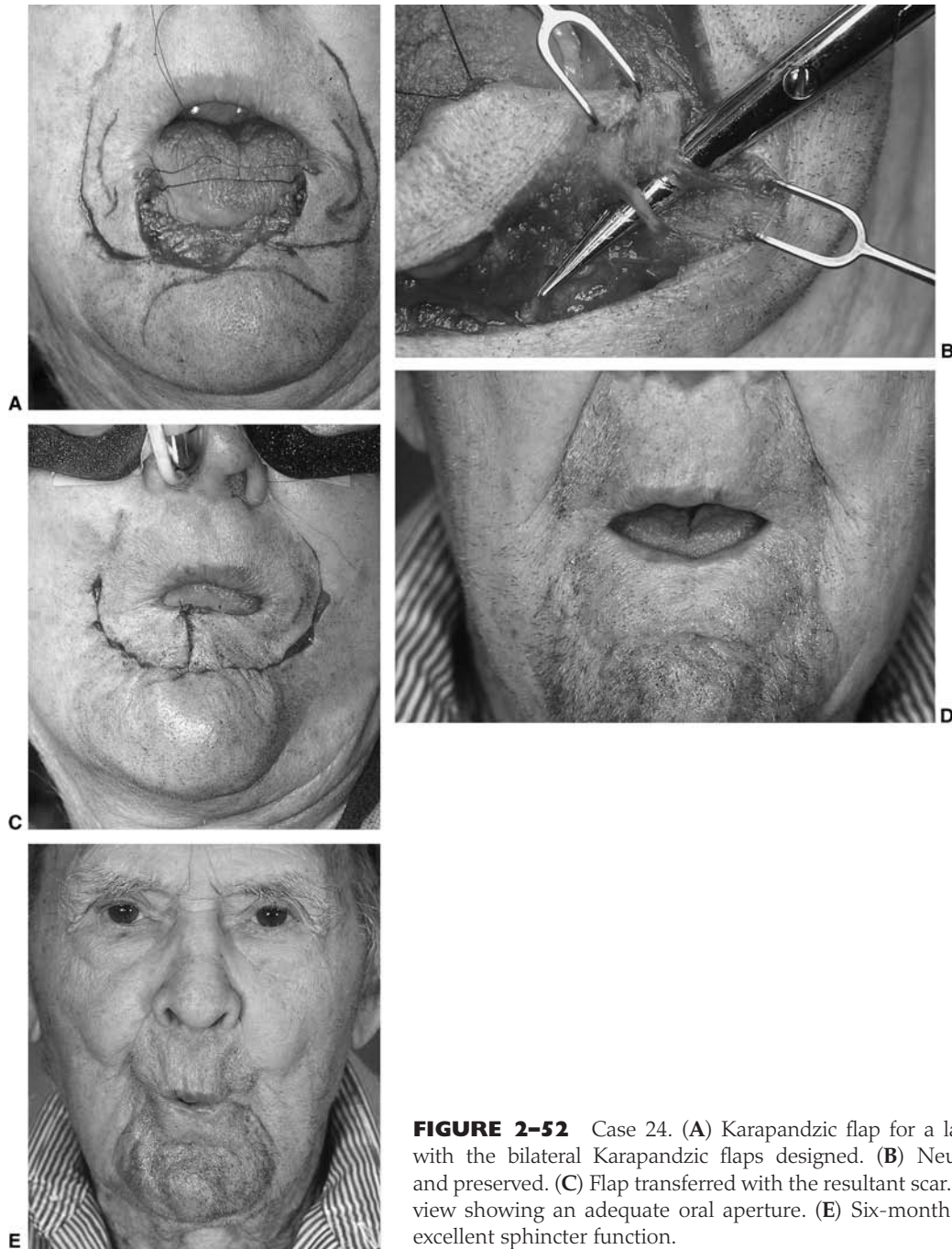


FIGURE 2-52 Case 24. (A) Karapandzic flap for a large, central, lower lip defect with the bilateral Karapandzic flaps designed. (B) Neurovascular arcade identified and preserved. (C) Flap transferred with the resultant scar. (D) Six-month postoperative view showing an adequate oral aperture. (E) Six-month postoperative view showing excellent sphincter function.

bridge a lateral canthal tendon defect when elevated as a hinged flap, based medially, and turned over to suspend the remaining tarsus.⁸⁸ The cutaneous portion of these larger deficits can usually be repaired with local tissues, recruited from the opposite lid, cheek, or temple area, and transposed as an advancement/rotation flap (Fig. 2-55). Because normal eyelid skin is devoid of subcutaneous fat, the rotational flap should be aggressively thinned, leaving only a thin layer of subdermal fat. It is

also essential to anchor the flap to the periosteum of the inferior orbital rim or malar eminence to ensure that no vertical tension is created on the lower lid margin. When the soft tissues are inadequate, one can drill a hole in the bone margin, through which the suspension suture can be passed. The conjunctival defect is analogous to the internal lining of the nose in that it is easily overlooked but must be addressed in some fashion. Free grafts from either the buccal surface or hard palate are often used for

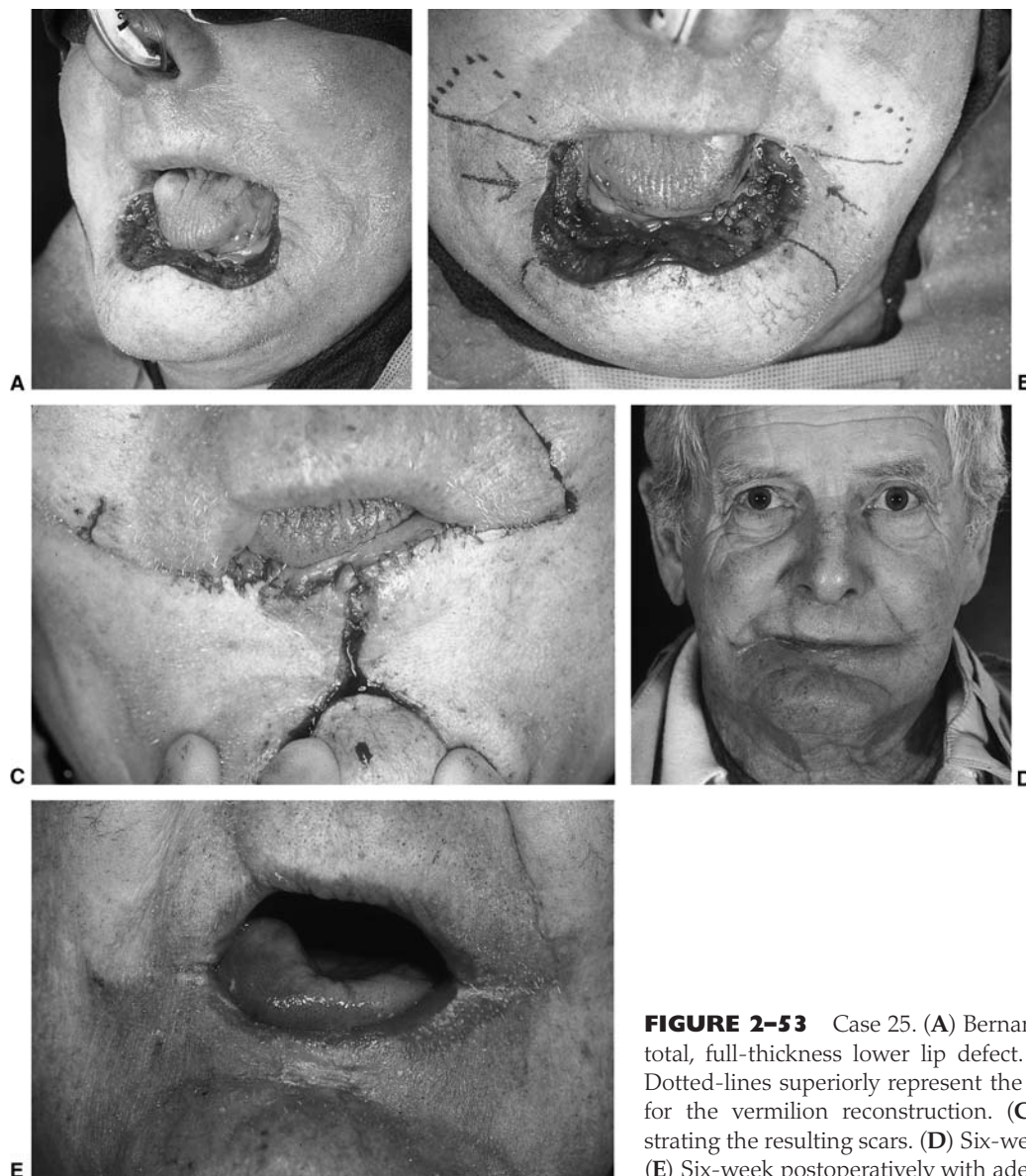


FIGURE 2-53 Case 25. (A) Bernard-Burrow-Webster flaps for a total, full-thickness lower lip defect. (B) Bilateral flaps designed. Dotted-lines superiorly represent the mucosal incisions to be used for the vermilion reconstruction. (C) Flaps transposed demonstrating the resulting scars. (D) Six-week postoperative frontal view. (E) Six-week postoperatively with adequate oral aperture.

this purpose. Larger defects of the posterior lamella can require a tarsal-conjunctival flap from the upper lid. This Hughes flap is an interpolated flap of upper conjunctiva and the superior half of the tarsal plate.⁸⁹ It is based on the levator aponeurosis and Müller's muscle above, and is mobilized inferiorly, over the eye. This pedicle is then divided 3 to 5 weeks later in the office.

The medial canthal area has several anatomic nuances that must be considered. The natural concavity of this region predisposes for webbing. To prevent the effects of wound contracture, it is suggested to breakup a linear scar with either a small Z-plasty or triangular flap. The lacrimal system can be violated in some eyelid defects and should be investigated through dilating and probing each punctum individually. When only a small disruption

has occurred, it can be closed primarily over a silicone intubation stent, which is left in place for about 6 weeks. This stent passes through the upper and lower canaliculi and is tied together in the nose, as it exits in the inferior meatus. Larger defects of the lacrimal apparatus most often require a formal dacryocystorhinostomy (DCR) and possibly a permanent Jones tube, which is a permanent prosthetic device used to drain the medial canthus.

The anterior crus of the medial canthal tendon is normally attached to the anterior lacrimal crest and can be dislodged from the primary defect. If the defect is limited to the anterior crus, it can usually be reattached primarily. When the posterior crus is disrupted as well, the reconstruction is similar to techniques for a naso-orbital-ethmoid (NOE) fracture; the medial canthal

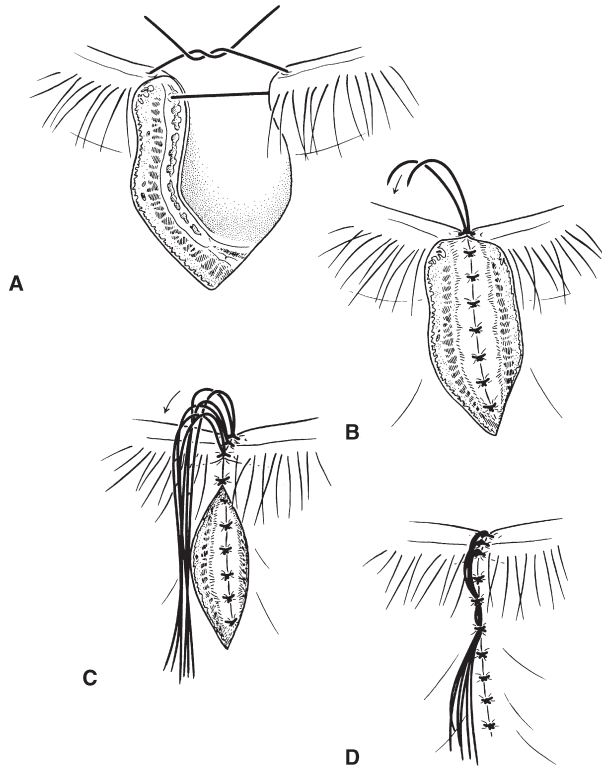


FIGURE 2-54 Eyelid repair. (A) A 6-0 silk suture through the gray line. (B) The tarsal plate closed with 6-0 resorbable suture. (C) The remaining lid margin is closed with silk and tags are left long. (D) The tags of the sutures tacked down to the skin sutures to avoid irritation.

tendon should be resuspended medially, posteriorly, and superiorly. Transnasal wiring can be accomplished through bilateral Lynch incisions or unilateral suspension to a microplate, anchored to the ipsilateral lacrimal bone or frontal process of the maxilla, then projected posteriorly.

AURICLE

Reconstructing an auricular defect presents unique challenges because of the complex topography, the ridges and valleys, and because of the subtle contours of the normal ear. Simultaneously, there are advantages with auricular reconstruction that are equally unique. Portions of the ear can be easily concealed with hair. Precise symmetry is less important because of the infrequency with which one sees both ears simultaneously; the true frontal view is an uncommon perspective. Moreover, an ear, like the nose, does not define beauty and ideally blends in with the face, remaining inconspicuous to the casual observer; although other features, such as the eyes, cheek bones, and lips, play a greater role in defining facial beauty. The lateral skin of the ear is firmly adherent to the undulating contours of the auricular cartilage and is deficient in subcutaneous fat. Consequently, most regional flaps are too bulky and will obscure the natural troughs and peaks of the ear.

The first goal in auricular reconstruction is to preserve or restore the general shape of an ear, i.e., the oval contour of the helical rim. The vertical position, projection, and orientation (15 degree posterior slant) are also important contributors in the reconstructive algorithm. The details of the ear, such as the scaphoid fossa, concha cyma, etc., are secondary factors in terms of the successful repair. Once this is recognized, an algorithm can be established that assists with selecting the method of repair for a variety of defects, both cutaneous and composite.

The initial step in evaluation of the auricular defect is the depth. Defects that are cutaneous only, regardless of size, are usually best repaired with a full-thickness skin graft, and this represents the first choice for a majority of repairs of auricular defects by Mohs' surgery. Although the disadvantages of lack of color and texture match exist, the skin graft remains superior to any local or



FIGURE 2-55 Case 26. (A) A cutaneous defect involving the right lower eyelid and lateral commissure. (B) Flap transposition from the upper eyelid showing the resultant scars.



FIGURE 2-56 Case 27. (A) A large cutaneous defect of the central ear. (B) Six weeks following the full-thickness skin graft. Note preservation of the auricular contours.

regional cutaneous flap (Fig. 2-56). Local skin flaps are inevitably bulky, and the auricular cartilage is not substantial enough to support it. When bare cartilage is exposed, it is often possible to excise certain areas of cartilage as long as the helical rim is supported, thus leaving the posterior perichondrium to support the skin graft. In this way, the auricular contour and height are preserved. An exception to this rule is the skin-only defect involving either the helical rim or the ear lobule. Although there is no native cartilage in the lobule, a skin graft will contract and the long-term result will be a deformed ear lobe. One must place a platform of cartilage support within the lobule to preserve the natural contour. If the defect is superficial, the graft can be inserted into a subcutaneous pocket within the lobule, and then followed with a skin graft. Deeper defects require the graft to sit on the defect, thus necessitating a vascularized local skin flap. Skin grafts to the helical rim also leave a contour problem. This subunit of the ear has a thick layer of subcutaneous fat surrounding the helical cartilage. A skin graft on the cartilage does not re-create the round form of the normal helical rim.

Composite defects, especially along the helical rim, often do well with a chondrocutaneous local flap that restores the oval contour of the ear. Although this sacrifices auricular height, at least a 20% discrepancy between ears generally goes unnoticed. Helical advancement flaps, wedge excision, and star excisions represent the workhorses for repair of smaller composite defects of the outer ear. The wedge excision is usually centered to the root of the helix, and a small tongue-and-groove excision allows the skin closure to be supported by the rim of cartilage. The cartilage edges should be firmly approximated with a long-lasting suture to resist the spring and recoil found in the elastic auricular cartilage. The limitation with a

wide wedge excision is the progressive cupping deformity that arises from excessive shortening of the outer helical rim with respect to the conchal bowl. When this occurs, a “star” excision can be designed, which is similar to the primary wedge but incorporates small triangular excisions within the conchal bowl or scaphoid fossa. These excisions are effectively removing standing cutaneous deformities of the ear (Fig. 2-57). Helical advancement flaps are composite flaps of helical cartilage and overlying skin that are well suited for small helical rim defects. They can be designed in one of two ways: full-thickness incisions inside the helical rim, or leaving the posterior/medial surface skin intact. The latter has the advantage of a greater vascular perfusion but is also more involved and requires the dead space to be obliterated (Fig. 2-58).

Larger composite defects require a layered reconstruction that includes structural grafting and resurfacing. The framework is usually rebuilt with cartilage grafts harvested from the septum, contralateral ear, or rib. The latter provides a supply of cartilage that can be assembled into a framework for rebuilding the entire ear, as is needed in microtia repair (Fig. 2-59). As a general rule, one should overcorrect and exaggerate the auricular landmarks. The resurfacing aspect must bring its own blood supply because it is covering avascular grafts. The non-hair-bearing skin of the postauricular area is ideally suited for a regional flap that can drape over the cartilage grafts. The infraauricular and postauricular skin can be elevated and mobilized anteriorly to cover the lower two thirds of the ear, releasing the skin flap peripherally 3 weeks later. One should avoid bringing hair-bearing scalp onto the ear.

When resurfacing the upper pole of the ear, the temporal parietal fascia flap can be elevated, based on the

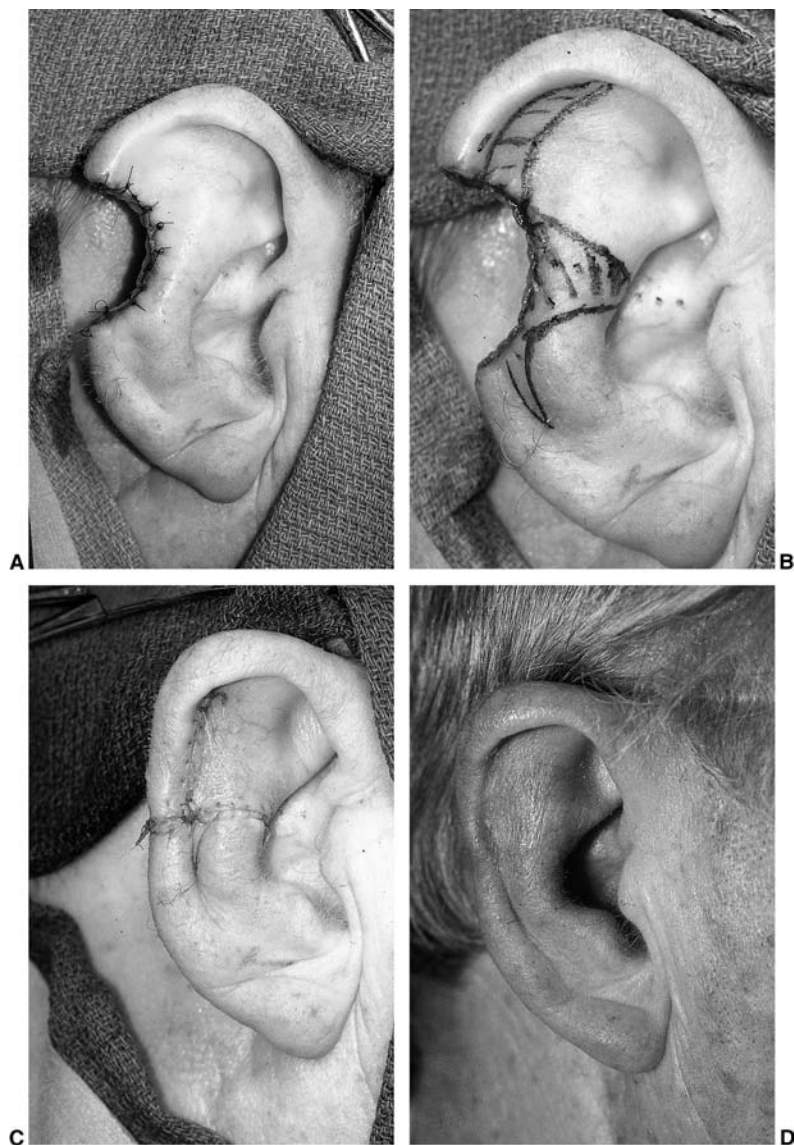


FIGURE 2-57 Case 28. (A) A star excision for a full-thickness right auricular defect. (B) The star excision is outlined with triangles in the scaphoid fossa. (C) Flaps transposed with resultant scars. (D) Three-month postoperative view showing preservation of the auricular contour.

superficial temporal artery, and draped over the grafted ear. The temporoparietal fascia (TPF) is immediately deep to the temporal scalp and is continuous with the galea superiorly. Its separation from the scalp is a tedious and deliberate dissection that should be kept just below the hair follicles. It provides a versatile flap that is uniquely thin yet vascular and dependable (Fig. 2-60). The TPF should not be confused with the deep temporal fascia, which is a thicker, striated fascia located immediately deep to the TPF. The deep temporal fascia is the landmark one penetrates during a Gillies approach to the zygomatic arch. Once the temporoparietal fascia flap (TPFF) is draped over the cartilaginous framework, a full-thickness skin graft can be secured for epithelial coverage. The TPFF nourishes both the cartilage graft and skin graft (Fig. 2-61) (Table 2-6).

SUMMARY

Cutaneous lesions of the face and neck are an important part of the otolaryngology practice, and differentiating between those that mandate immediate intervention and those that typically take an indolent course is a difficult clinical skill to acquire. There are a few essential characteristics that help with this distinction, many of which have been reviewed. Selecting the definitive treatment for these cutaneous lesions is equally challenging and critical. Some lesions can be managed in a conservative fashion with topical creams, yet others require surgical treatment, at times with Mohs' micrographic surgery or even with staging lymphatic dissections. Having a framework on which one can base these decisions is essential, and this has been reviewed in this chapter.

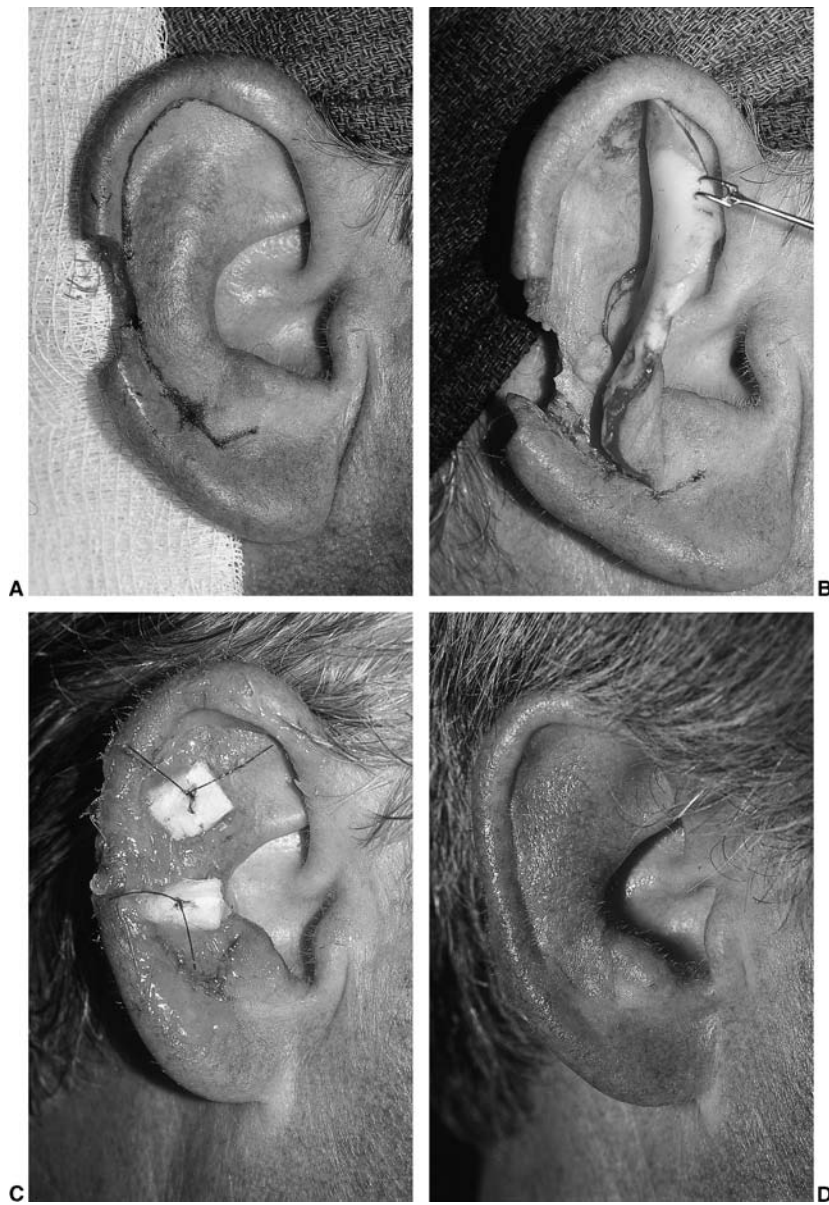


FIGURE 2-58 Case 29. (A) Helical flap for a right helical defect with the flaps designed. (B) Preservation of the posterior auricular skin with the helical advancement flaps. (C) Bilateral helical advancement flaps closed with bolster sutures to obliterate the dead space. (D) Six-week postoperative view showing acceptable helical contour.

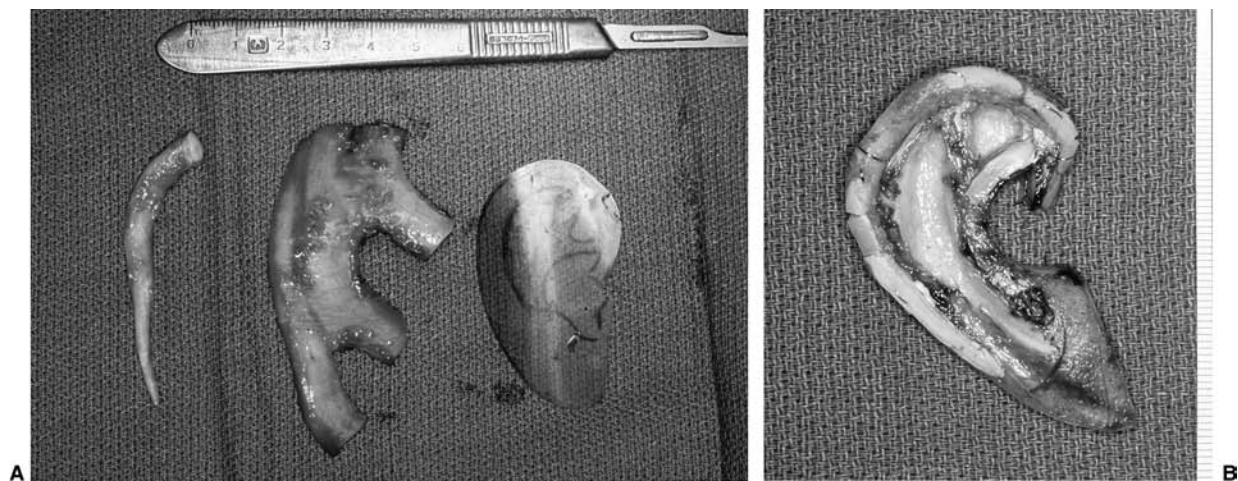


FIGURE 2-59 (A,B) Costal cartilage assembled into an ear.



FIGURE 2-60 Temporoparietal fascial flap (TPFF). Note the thin, pliable, vascular characteristics.

TABLE 2-6 AURICULAR RECONSTRUCTION ALGORITHM

Skin only defect (except helical rim)	Full-thickness skin graft Excise cartilage as needed and permitted
Helical rim defect (<1 cm)	Helical advancement flaps
Helical rim defect (1–2 cm)	Wedge or star excision
Composite defects of the lower two thirds	Structural cartilage graft Local cutaneous flap
Composite defects involving the upper one third	Structural cartilage graft Temporoparietal fascial flap Skin graft

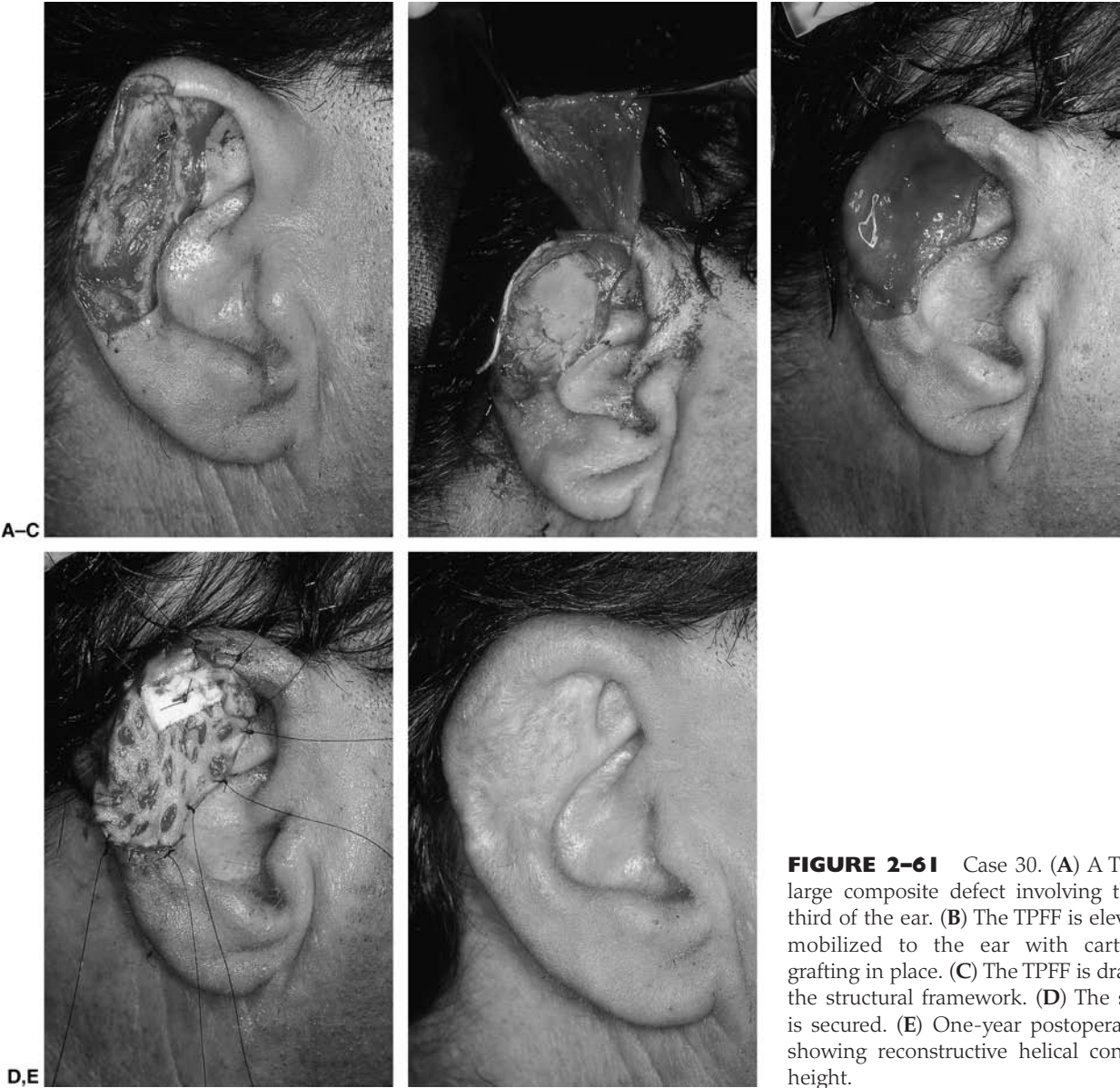


FIGURE 2-61 Case 30. (A) A TPFF for a large composite defect involving the upper third of the ear. (B) The TPFF is elevated and mobilized to the ear with cartilaginous grafting in place. (C) The TPFF is draped over the structural framework. (D) The skin graft is secured. (E) One-year postoperative view showing reconstructive helical contour and height.

Finally, the optimal surgical repair of cutaneous defects, whether from Mohs' surgery, trauma, or idiopathic conditions, is a technically and intellectually challenging aspect of otolaryngology. This task calls on a creative and three-dimensional cognitive skill and is in distinct contrast with the conventional recall and "left brain" activity we most often utilize. Trying to envision the resultant scars, vectors of tension, and long-term aesthetic/functional results, is infinitely challenging and rewarding. It is precisely this abstract challenge that continually feeds our interest and enthusiasms for a practice in facial plastic surgery.

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HEAD AND NECK RECONSTRUCTION

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Head and neck reconstruction often refers to the aesthetic and functional rehabilitative efforts involving major traumatic and postsurgical oncologic defects. These reconstructive procedures may include replacement of lost tissues extending from the cutaneous to the mucosal regions of the head and neck including skin, muscle, neurovascular components, bone, and mucosal coverage. Challenges of head and neck reconstruction include but are not limited to restoration of the special senses in addition to voice, swallowing, speech, breathing and even the aesthetics of emotion in facial animation. This chapter discusses reconstruction and rehabilitation of the common postoncologic defects and is based on the most widely accepted state-of-the-art techniques for the specific recipient sites listed. It is not intended to be an all-inclusive, comprehensive review but rather a concise reference for those approaching the more common defects with a desire for the best functional and aesthetic outcome with the standard techniques currently used and available.

RECONSTRUCTION OF MAJOR HEAD AND NECK DEFECTS

Surgical reconstruction of head and neck defects originally consisted of second-intention healing, skin grafts, primary closure, and locoregional random flap reconstructions.¹⁻³ It was not until the use of various neck and forehead flaps followed by the use of the deltopectoral flap that larger defects could be reconstructed or closed.⁴⁻⁹ Expanded use of these flaps exposed several problems including limited length, arc of rotation, and unreliability, whereas more reliable and lengthy regional flaps such as the pectoralis and other myocutaneous flaps became the mainstay for reconstruction of larger defects following cancer surgery.¹⁰⁻¹⁵ The innovative and customized techniques beginning with the pectoralis myocutaneous and osteocutaneous regional flaps

provided the framework on which microvascular free tissue transfers were applied to the head and neck and the future of head and neck reconstruction was born.

ONCOLOGIC AND RECONSTRUCTIVE ISSUES

Reconstruction of the head and neck region must address a variety of functional and cosmetic areas that are apparent in public on a daily basis. Thus, the goals of head and neck reconstruction include a general plan to provide the least morbidity in returning patients to their pretreatment or original function and aesthetics. It should be mentioned at the outset that the curative intentions of a procedure should not be compromised to provide for a particular reconstructive option except under extenuating circumstances as agreed on by the treating and reconstructive teams with the patient and family. The primary goal, therefore, is to provide the patient with the best possible life expectancy through reconstruction aimed at also providing the best quality of life and patient satisfaction. In certain cases, this may include delayed reconstruction to provide the ability to “monitor” a wound for recurrent disease for a period of time prior to the definitive reconstruction. A second goal, yet often equally important, is to provide for functional breathing, chewing, speech, and swallowing by means of reconstructive opportunities. Further refinements in functional reconstruction should address mastication and dental rehabilitation, sensation, salivary flow, taste, and articulation, among others.

The cosmetic result remains a priority to the reconstructive surgeon but it should be weighed with the patient’s desires in relationship to the aforementioned goals. It is not always possible to provide the best cure rate, functional reconstructive option, and optimal aesthetic outcome with a single flap reconstruction. The patient and family should be well educated about these issues prior to surgery and about the expected outcomes, risks, complications, and options.

TABLE 3-1

<i>Flap</i>	<i>Primary Arterial Supply</i>	<i>Venous Outflow</i>	<i>Nerve</i>	<i>Tissue</i>	<i>Advantages</i>	<i>Disadvantage</i>
Pectoralis	Pectoral branch of thoraco-acromial, lateral thoracic	Pectoral	Pectoral	SFAM	Reliable	Bulky, insensate, shoulder dysfunction, difficult to contour, donor site morbidity/ deformity
Trapezius superior	Intercostal, occipital	Intercostal	Spinal accessory	SFAM	Adjacent tissue to head and neck, adequate reach	Limited arc of rotation, thin after atrophy
Trapezius, lower	Transverse cervical (dorsal scapular)	Transverse cervical (dorsal scapular)	Transverse cervical	SFAM	Large, thin flap, extended length	Intraoperative positioning, difficult harvest, thin after atrophy
Trapezius, lateral island	Transverse cervical	Transverse cervical	Transverse cervical	SFAM	Large, thin flap	Difficult harvest, intraoperative positioning, thin after atrophy
Latissimus dorsi	Thoraco-dorsal	Thoraco-dorsal	Thoraco-dorsal	SFAM	Thin, reliable, large surface area, motor potential	Intraoperative positioning
Deltpectoral	Intercostal perforators 1–4	Intercostal perforators 1–4	None	SFA	Simple technique, in operative field, ease of harvest	Limited arc of rotation, extension requires delay, cosmesis
Platysma	Facial	Facial	Cervical	SFAM	Thin, no donor morbidity	Skin slough, limited skin area
Sternocleidomastoid	Occipital, superior thyroid, transverse cervical	Occipital, superior thyroid, transverse cervical	Spinal accessory, cervical plexus	SFAM, perosteum	In field of head and neck, reliable for local coverage	Poor vascularity, limited rotation, loss of vascular coverage, unreliable for mucosal closure
Submental	Submental branch of facial	Submental vein, venae comitantes	None	SA	Reliable, local tissue, ease of harvest	Limited rotation, potential oncologic compromise
Superficial temporoparietal	Superficial temporal	Superficial temporal	None	F	Reliable, easy access	Thin, risk to facial nerve
Temporalis	Deep temporal	Deep temporal	None	FM	Reliable, adjacent region	Possible cosmetic defect

S, skin; F, fascia; A, adipose; M, muscle.

One of the obvious advances in head and neck cancer over the past half century has been the increasing variety of reconstructive options allowing surgical resection of larger tumors involving structures vital to functional and aesthetic rehabilitation. The current concept of reconstructing missing tissue with similar tissue and the potential for vascular and neural input allows patients improved quality of life and has provided patients with

historically unresectable tumors (or “unreconstructable”) the option of surgical resection. In any reconstruction there are considerations of both donor site and recipient site defects, morbidity, and functional and aesthetic results. For cutaneous defects, the skin color and thickness are especially important, but with composite flaps in through-and-through defects the skin color match is not the top priority. For large mucosal defects, cosmesis

is of less importance as function becomes the top priority. With all of these considerations, the head and neck reconstructive surgeon should remember that the type of reconstruction or combination of reconstructions affording the patient the best cosmetic result, quality of life, and least donor site morbidity is often the method of choice. The following surgical reconstructive techniques are divided into pedicled flap reconstruction and free tissue transfer reconstruction.

PREOPERATIVE PLANNING

It is critical for the ablative surgeon to communicate with the reconstructive surgeon about the planned surgical procedure, approach, and expected reconstruction well in advance of the procedure. The reconstructive surgeon may often order additional studies based on the location of the tumor, planned reconstruction, comorbidities, and patient occupation or avocation prior to surgery. Presence of adequate vascular structures in the neck may require confirmation by examination, ultrasound, arteriography, or computed tomography (CT) or magnetic resonance imaging (MRI) scanning prior to free tissue transfer. The numerous regional flaps based on vascular structures surrounding the head and neck regions require detailed knowledge about, and experience with, the vascularity of the region, whereas the expanding use of free tissue transfer demands meticulous dissection and care of these same vessels for recipient microvascular anastomosis. Although much focus is given to surgical techniques, consideration should always be given to prosthetic rehabilitation and emerging technologies. For example, a patient with an oral cancer may benefit from an intermediate or permanent obturator or stent through consultation with a maxillofacial prosthodontist in combination with surgical reconstruction. Many maxillary and palatal cancers can be rehabilitated with either surgical techniques or prosthetic appliances.

Patient positioning, planned incisions, preparation, and instrumentation are often modified according to the technique planned. Most major defects of the head and neck are ideally reconstructed at the time of surgical extirpation, which provides immediate functional and aesthetic improvement preventing extensive scarring, fibrosis, and other morbidities.

PEDICLED FLAPS

Pedicled flaps used in head and neck reconstruction commonly are used in a primary reconstruction, although delaying these flaps can provide additional length when necessary. The common flaps applied to this region are listed in Table 3–1 and are supplied by axial

blood supply from the head, neck, or trunk in the majority of cases. These flaps are described with an emphasis on the more commonly used procedures.

FASCIOCUTANEOUS FLAPS

DELTOPECTORAL FLAP

Originally described by Bakamjian, who reported first using this technique in 1962, this flap remains an option for head and neck reconstruction, although its limited arc of rotation may limit its application to certain defects of the head and neck and pharynx unless delayed.^{6,16} The flap is a fasciocutaneous axial flap based on the first four intercostal perforators with the majority of the blood supply from the second and third branches of the internal mammary artery. The flap should be preserved in all patients undergoing a pectoralis myocutaneous (PMC) flap due to the potential division of the deltopectoral (DP) flap during incisions for exposure of the PMC flap. This provides a “backup flap” for any future reconstructive needs. It also provides excellent vascularized coverage of the peristomal and lower pharyngeal region as a one-stage axial flap when the flap does not extend beyond the DP groove. When an extended length flap is necessary, the flap usually requires a delay procedure 3 to 4 weeks prior to transfer of the extended flap into the deltoid region. With delay, the flap has been used to cover most regions of the head and neck. The major disadvantages of the DP flap are the limited arc of rotation and length of flap and the donor site defect, which can be unsightly with the skin graft coverage. When used for total pharyngeal defects, concerns include a high rate of stricture and fistula formation.

Technique

The flap should be outlined prior to any PMC flap harvest and it is recommended to outline the delayed extended DP flap in case additional tissue is necessary (Fig. 3–1). During the first stage, the flap is marked along the inferior border of the clavicle from the sternal notch to the acromioclavicular joint. It then takes a gentle curve well beyond the DP groove over the shoulder and inferiorly to 1 cm superior to the axillary crease to meet the inferior border along the fourth intercostal space to the sternum. An operative towel or sponge is used to provide a template to determine the arc and distal limits of the flap prior to the incisions, holding one end firm at the junction of the sternum and fourth intercostal space and rotating the towel toward the defect. If additional length is required, the incision can be extended at this time, or a back cut can be performed at the inferior aspect, taking care not to extend the cut to the depth of the vascular supply. The flap is then elevated from the distal tip to the DP groove in a subfascial plane. The flap is sutured back in position until

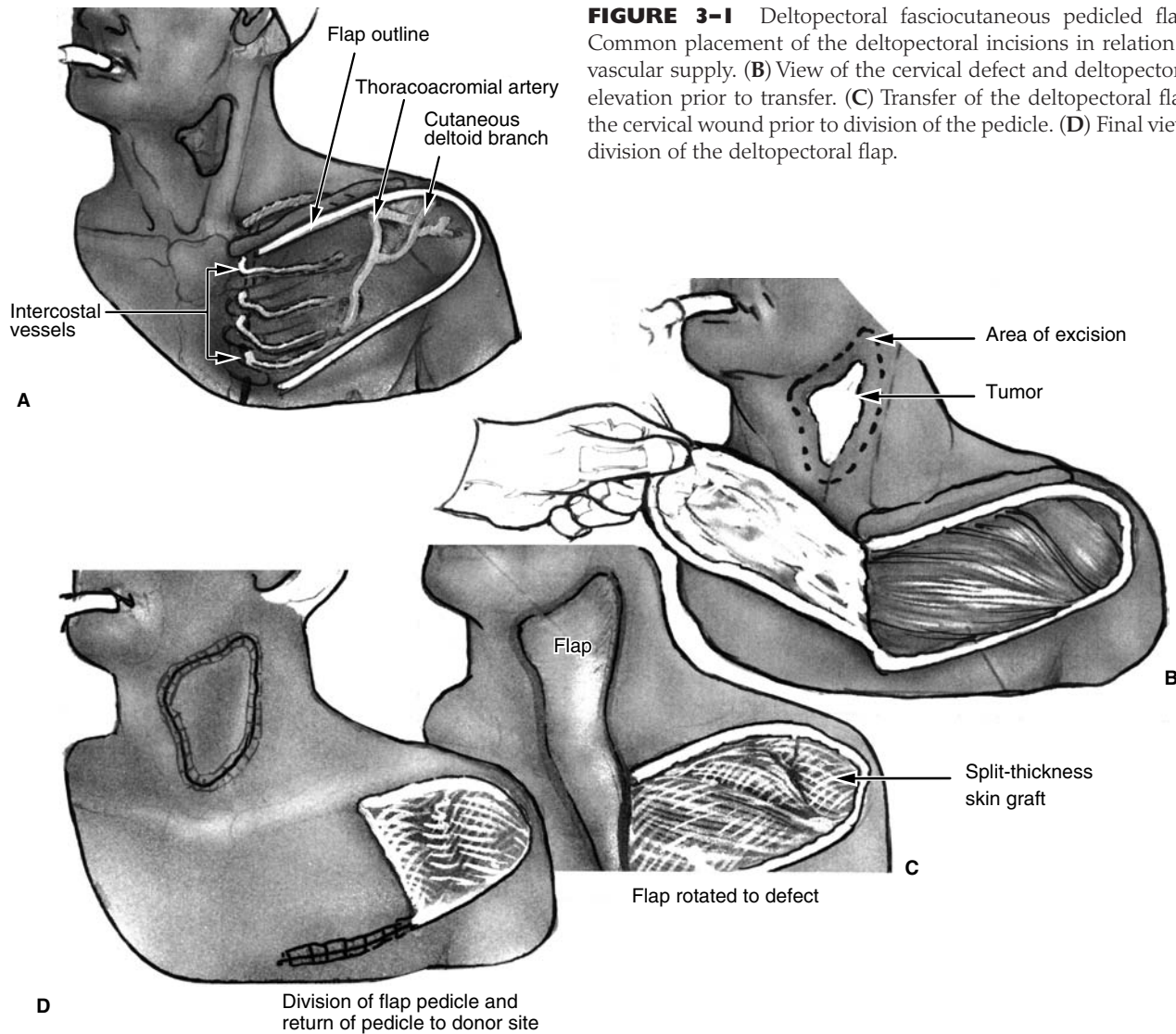


FIGURE 3-1 Deltopectoral fasciocutaneous pedicled flap. (A) Common placement of the deltopectoral incisions in relation to the vascular supply. (B) View of the cervical defect and deltopectoral flap elevation prior to transfer. (C) Transfer of the deltopectoral flap into the cervical wound prior to division of the pedicle. (D) Final view after division of the deltopectoral flap.

the second stage 3 to 4 weeks later. At the second stage, the flap should have no separation or necrosis and can be elevated in the same plane to within 2 cm of the lateral edge of the sternum where the perforators can usually be visualized entering the flap. The flap is then transferred into position and sutured into place. The donor site is covered with a petrolatum-based gauze while the lateral half of the wound is covered with a split-thickness skin graft. The flap can then be released 3 to 4 weeks later if the base is to be returned to the donor site. Physical therapy is usually required to prevent significant fibrosis and scar contracture of the upper chest and shoulder.

MYOCUTANEOUS FLAPS

PECTORALIS FLAP

The pectoralis myocutaneous regional pedicled flap (PMC flap) was originally transferred for chest wall

defects but widespread use in the head and neck region for a variety of defects resulted in head and neck applications outnumbering those for chest reconstruction.^{13,17,18} The PMC flap remains the workhorse flap for head and neck reconstruction more than two decades after it was given this title. The flap provides adequate, vascularized soft tissue coverage for many head and neck defects with minimal donor site morbidity and high success rates. Complete flap failure rates remain less than 3%; however, there is considerable evidence that partial failure, flap separation, dehiscence, or fistula formation occurs in up to 30% of cases.¹⁹ The flap remains limited in length by its vascular pedicle, although further lengthening can be performed by resecting a segment of clavicle. The PMC flap remains an excellent “backup” flap if tumor extirpative surgery results in a defect that cannot be closed primarily or for failure or less than ideal conditions with other reconstructive options. Outcomes analysis of PMC flaps

versus other flaps are limited to specific areas and indications and cannot be generalized. It is obvious that the PMC flap is going to remain a reconstructive option in the head and neck for years if not decades to come.

Anatomic Considerations

The PMC flap is composed of (from deep to superficial) deep pectoral fascia, pectoralis major muscle, superficial pectoral fascia, adipose tissue, and skin. It is a fan-shaped muscle with origin from the medial half of the clavicle onto the sternum and cartilages of the second to sixth ribs. It courses superolaterally to insert into the crest of the greater tubercle of the humerus. It acts to flex, adduct, and rotate the arm and shoulder medially, thus revealing the importance of physical rehabilitation when this flap is used in reconstruction. The vascular supply is derived from the two major branches of the second part of the axillary artery, the thoracoacromial and lateral thoracic, although the major flow is through the pectoral branch of the thoracoacromial.²⁰ It is supplied by the motor branches of the medial and lateral pectoral nerves from the brachial plexus with supply from the fifth to eighth cervical and first thoracic nerves. Other anatomic structures that should be well understood in harvesting the flap include the intercostal perforators to the chest and DP flap, the intercostal muscles, pleura, clavicle, anterior costal cartilage and ribs, rectus abdominis muscle, pectoralis minor muscle, and anterior serratus muscle.

Indications

The indications for the PMC flap include mucosal defects extending from the level of the soft palate anteriorly to the floor of mouth and inferiorly to the cervical esophagus. The PMC flap has the potential reach for skin and soft tissue defects from the periauricular region to the perioral region and the entire neck. An extended PMC flap with a random distal extension may reach to the temporal bone and maxillary region.

Advantages

The advantages of this flap include its reliability and source of vascularized tissue in an area adjacent to the head and neck but not exposed to treatment-related radiation therapy or prior scar from head and neck surgery. It provides skin, adipose, and muscle bulk that may result in thinner coverage from muscle atrophy when the pectoral nerves are divided at the time of harvest. Its application can be applied to most any defect in the head and neck region except for the most cranial regions due to its limited reach.

Disadvantages

The disadvantages of the flap are related to attempts to use it to replace bone or in upper pharyngeal and oral

defects. It is insensate, and the thick skin and excess bulk may prevent a return to normal speech and swallowing. The flap is not the ideal flap for osseous defects but has been successfully used to fill in bone defects with or without plating in the oromandibular region. When used in total pharyngeal reconstruction, it does have a high rate of fistula and stricture formation compared with other techniques such as the jejunal free flap and tubed radial forearm free flap. Donor site morbidity includes significant scar and asymmetry to the chest wall and soft tissue bulging over the clavicle. Therefore, a surgeon should not consider it as the only flap to reconstruct head and neck defects. Careful patient selection does, in some cases, necessitate its use when microvascular reconstructions are not available or contraindicated. The arm and shoulder function may be affected particularly in patients undergoing extensive neck dissection or in those unable to complete proper physical therapy after surgery.

Technique

The flap is usually transferred as a myocutaneous flap, which is described here (Fig. 3–2). The expected recipient site is analyzed to determine the geographic relationship and route of transfer of the PMC flap, taking into account that the flap usually must run deep to the existing neck skin, further limiting its length. As with the DP flap, a gauze template is used to estimate the necessary length and arc of rotation, allowing for orientation of the skin paddle. Once the planned cutaneous flap measurements are available, they are marked in the inferomedial chest between the sternum and nipple with possible extensions into the abdomen or proximally in the chest. The incision is made through skin, subcutaneous tissue, and pectoralis muscle fascia. The fascia is secured to the dermis initially to decrease the risk of shearing of the flap from the muscular perforators. Wide undermining is performed circumferentially away from the paddle to provide exposure to the muscle and vascular pedicle and to facilitate eventual closure of the donor site, which rarely requires skin grafting. Superior undermining in the subfascial plane continues superficial to the clavicle to connect with the neck subplatysmal flap elevation. It is helpful to widen the tunnel to allow easy passage of the surgeon's hand to prevent compression of the muscle and pedicle. The lateral border of the pectoralis major muscle is identified and elevated from the chest wall to visualize the vascular pedicle. The pectoral branch and the lateral thoracic artery can usually be identified, and, if possible, both are preserved. The muscle is then divided distal to the flap, which sometimes requires separation of a portion of the rectus abdominis muscle. The entire skin, adipose, and muscle are elevated from the chest wall to the pectoralis minor muscle and beyond to the level of the clavicle. Small intercostal perforators enter the muscle through the

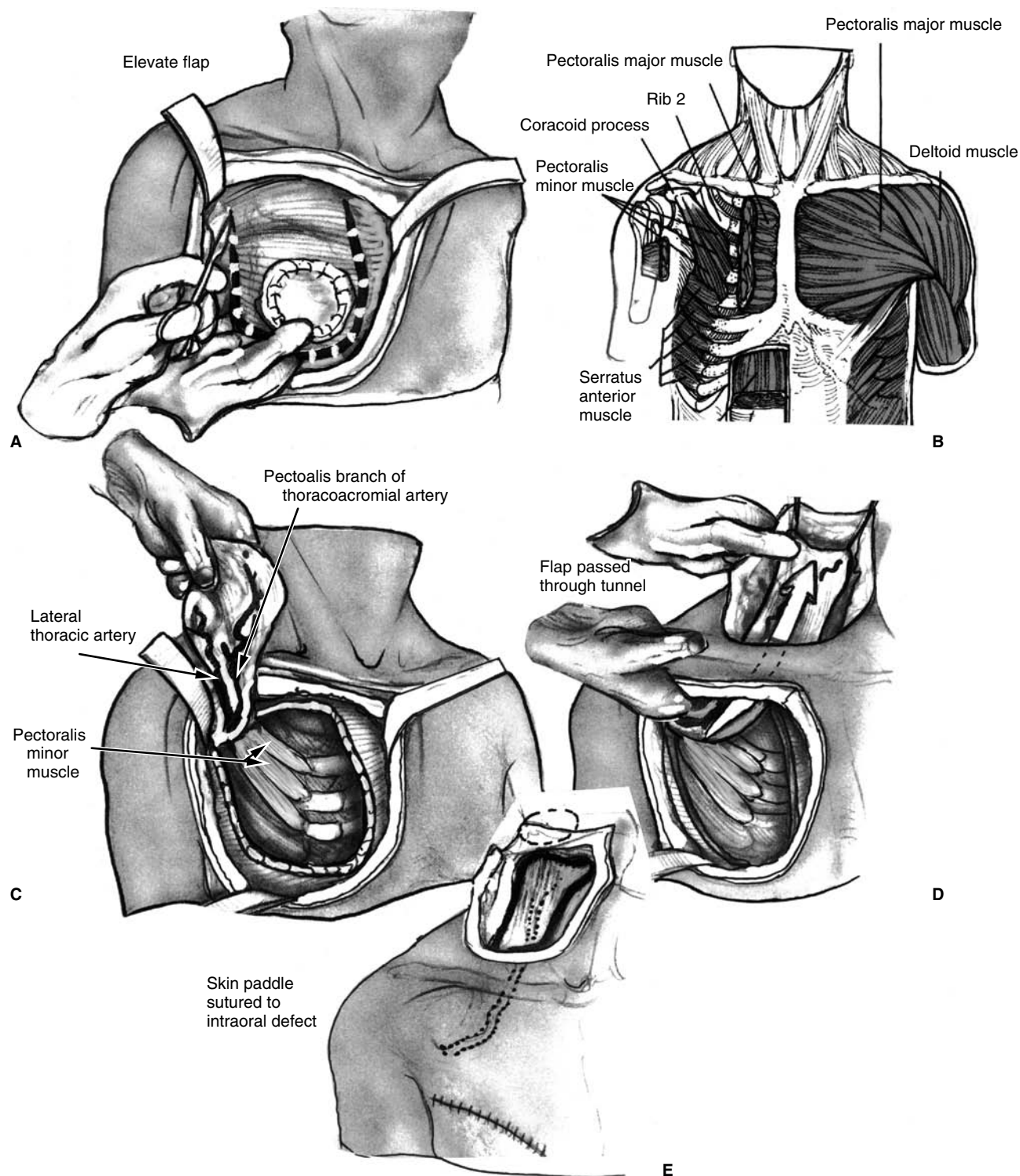


FIGURE 3-2 Pectoralis myocutaneous pedicled flap. (A) Placement of incisions for the pectoralis myocutaneous flap with skin elevation and planned muscle division incisions. (B) Anatomic structures deep to the pectoralis muscle on the right as viewed during elevation of the pectoralis myocutaneous flap. (C) View during elevation of the pectoralis myocutaneous flap from the anterior chest wall. (D) Tunneling of the flap deep to skin encompassed within the deltopectoral flap region into the neck. (E) Flap placement deep to the neck skin with the intraoral flap inset not visible.

chest wall and should be ligated. The flap can then be tunneled into position by passing an Allis clamp and grasping the subcutaneous tissue pulling the flap into the neck and taking great care that the flap is not twisted. Closure of the chest wound is done with a two-layer closure, and a drain is placed inferiorly and laterally to prevent hematoma formation. The PMC flap is a heavy flap, and gravity tends to pull the flap inferiorly away from the suture line unless several “antigravity” sutures are placed. The pectoral nerve is divided to prevent muscle contraction and suture dehiscence in addition to potentiating muscle atrophy.

LATISSIMUS DORSI FLAP

The latissimus dorsi myocutaneous flap (LDMF) is one of the few flaps that can be pedicled to reach almost any defect in the head and neck region. First described in 1896 by Tansini for chest wall reconstruction and developed for use in the head and neck by Quillen et al¹⁰ in 1978, it has been applied to defects of the scalp, maxillofacial region, skull base, mandible, and pharyngoesophagus.^{21–25}

As a myocutaneous flap it can be used for skin coverage and mucosal coverage, whereas the myofascial flap is often used to add bulk, cover vascular structures, and cover skull base and scalp defects. It is not often the primary flap used in head and neck reconstruction due to the convenient transfer of other pedicled myocutaneous flaps such as the pectoralis major and free tissue transfer, which often allows more customized flaps for particular defects. It is more often used in secondary reconstructive procedures or in procedures requiring flap reconstruction of the lateral skull base and scalp due to its extended length and thin soft tissue coverage. It has more recently been transferred as a free tissue transfer, which avoids the transaxillary dissection and postoperative concerns over positioning of the arm.

Anatomic Considerations

The latissimus dorsi is a thin, triangular-shaped muscle that covers the lower half of the lumbar region extending laterally to the abdominal wall musculature. The vascular supply to the muscle is primarily from the thoracodorsal artery, which is paralleled by a larger vein; however, the intercostal and lumbar perforating vessels supply the lower portion of the muscle and are not harvested with the myocutaneous pedicled flap.^{26,27} The thoracodorsal artery is the terminal branch of the subscapular branch of the axillary artery and usually provides a pedicle 7 to 10 cm in length from the branching off of the subscapular artery. The artery typically varies from 2.0 to 4.5 mm in diameter. Distal branches may allow splitting of the flap into two paddles when inner and outer lining of head and neck defects is necessary.²⁷ The thoracodorsal nerve from the posterior cord of the brachial plexus innervates the muscle, whereas the lateral cutaneous intercostal nerve supplies the skin of the region of the

distal muscle where the cutaneous paddle is often harvested. The muscle originates in a broad aponeurosis, which attaches to the lower six thoracic vertebrae along with the lumbar and sacral vertebrae. It has numerous attachments including the lower ribs and the posterior iliac crest. From this fan shape, it extends superolaterally attaching by fibers to the tip of the scapula to insert in the intertubercular groove of the humerus. The latissimus muscle functions by pulling the shoulder downward and backward while adducting, extending, and rotating the arm medially with the help of the pectoralis major.

Indications and Preoperative Planning

The latissimus dorsi pedicled flap (LDPF) is most often used for reconstruction of lateral neck, parotid, and temporal bone defects. It may also be required secondarily following recurrent cancer surgery or prior flap failure when other donor sites are not available. Caution should be exercised in patients who have had a previous axillary dissection or radiation for melanoma or breast cancer. In these cases, arteriography may be indicated to determine the patency of the vascular supply. Prior pectoralis flap harvest on the ipsilateral side may complicate the axillary dissection when this flap is transferred as a pedicled flap and also result in significant debilitation to the arm and shoulder function. The muscle is often palpable, and planning of the location of the skin paddle can be determined by having patients flex their arms with their hands on their hips.

Technique

The dimensions of the muscle are outlined prior to marking the skin paddle. The anterior border of the muscle is palpable and runs from the axillary crease to the posterior superior iliac crest. Doppler flow can be tested to confirm the location of the vascular pedicle if necessary, although the pedicle runs a reliable course deep and medial to the lateral border of the muscle. The patient is often positioned in a lateral decubitus position with a beanbag supporting the body and an axillary roll supporting the axilla, preventing brachial plexus injury. The flap can be harvested with a two-team approach if the extirpative surgeon has access to the extirpative site and a contralateral neck dissection is not necessary. The ipsilateral arm is wrapped in a stockinette and no intravenous (IV) or arterial line is placed in this arm. The skin paddle should be placed within the middle third of the muscle due to a more random pattern blood supply distally.

Flap Harvest

The initial incision surrounds the planned skin paddle and should include a curvilinear extension along the superior aspect of the muscle toward the axilla. Lateral to medial dissection exposes the lateral border of the latissimus

muscle and the vascular branches to the serratus anterior muscle, which, if followed, branch with the thoracodorsal vessels. Once these are identified, the branches to the serratus are ligated and the lateral to medial flap elevation from the thoracic wall is performed. The thoracodorsal vessels can then be dissected proximally into the axilla, identifying the angular artery to the tip of the scapula, the circumflex scapular artery, and the branch to the teres major muscle. This is facilitated by division of the muscle from the tip of the scapula, enhancing exposure. Once the vascular pedicle is identified and exposed, the entire muscle and skin paddle are dissected free distally to proximally. For the pedicled flap, a tunnel is then made between the pectoralis minor and major through which the flap is gently passed into the upper chest and neck region. Alternatively, depending on flap compression and prior surgical procedures, it can be tunneled subcutaneously through the axilla. During and following the procedure, the pedicled flap can be compressed by the arm and shoulder, causing thrombosis if it is not monitored carefully and arm position changed as necessary. The arm should be immobilized until flap viability and healing is assured. Any change in color requires evaluation by the surgical team. This flap has also been transferred with attached ninth rib as an osteomyocutaneous flap for mandible reconstruction, although the vascularity and eventual resorption of the bone can be a problem. As a free flap transfer, it is often combined with one of the variations of the scapula flap to include bone and adjacent skin paddles.

Advantages

The latissimus flap has an extremely long pedicle and transfer capability to most regions of the head and neck. It is reliable but requires intense monitoring to prevent thrombosis. In a large series of 68 cases over a 14-year period, Hayden et al²⁴ report only one case of total flap necrosis and six cases of partial flap necrosis. The flap provides a large surface area of thin cutaneous covering or vascularized tissue for soft tissue defects. It is the ideal flap for total scalp defects and provides nice shape and contour in radial parotidectomy and lateral temporal bone resections. It has minimal donor site morbidity that is usually improved with physical therapy.

Disadvantages

The major disadvantage is the need to modify the patient position intraoperatively or perform the procedure with the patient in the lateral decubitus position. Seroma formation represents one of the more common complications at the donor site.

TRAPEZIUS FLAP SYSTEM

The trapezius system of flaps has been described by several authors for a variety of soft tissue and

osteocutaneous defects in the head and neck region.^{12,13,28–30} The trapezius muscle is the central component in several flaps named the superior, lateral island, and lower trapezius flaps. These flaps are infrequently used relative to other regional flaps but are most applicable to defects of the lateral neck, lateral skull base, scalp, and maxillofacial region. The lateral island trapezius flap has been transferred with bone for mandibular and maxillofacial reconstruction.

SUPERIOR TRAPEZIUS FLAP

The superior trapezius flap is based primarily on the posterior superior intercostal perforating arteries with contributions from the occipital artery, and is the most convenient to use for head and neck reconstruction due to its position along the posterior neck and shoulder. Similar to the DP flap, it may require delay for extended length flaps to reach the anterior neck, oral cavity, and pharynx. It is limited by its arc of rotation in the posterior midline and usually requires a skin graft for closure of the donor site.

LATERAL ISLAND TRAPEZIUS FLAP

The lateral island trapezius flap is based on the transverse cervical artery and requires extensive dissection of this vessel into the neck to provide adequate mobility for rotation into more anterior regions of the head and neck. Its vascular supply may be tenuous in individuals previously treated with surgery or radiation to the neck region, and this represents a relative contraindication to the procedure. Both the superior and lateral island trapezius flaps can be performed with the patient in a semilateral decubitus position, whereas the lower trapezius flap must be done with complete exposure of the patient's lower back to the midline.

LOWER TRAPEZIUS FLAP

The lower trapezius flap is the most difficult to harvest of the three trapezius-based flaps but provides the most tissue that can be rotated to a wider array of recipient sites than superior and lateral flaps. Based on the deep branch of the transverse cervical often referred to as the dorsal scapular artery, this flap has less consistent vascular anatomy, and meticulous dissection of these distal branches of the transverse cervical vessels is required. The skin paddle is centered between the tip of the scapula and vertebral bodies in the mid-back, and a curvilinear incision is extended superiorly to identify the supplying vessels. The donor site can often be closed primarily with adequate drain placement prior to closure to prevent seroma formation.

TECHNIQUE

The harvest of these flaps generally includes the skin, subcutaneous tissue, and trapezius muscle, along with

meticulous technique in identifying and preserving the vascular pedicle. These flaps can be applied primarily to posterior neck, lateral neck, and temporal bone defects, although other flap options are typically preferred. Detailed information about the anatomy of the vascular supply and the flap harvest technique are well described in prior reports.^{30–32} Technical preparation is required prior to undertaking this flap harvest.

PLATYSMA FLAP

The platysma flap is a myocutaneous flap that is based on branches of the facial artery and can include venous drainage from the branches of the facial vein and external jugular vein.³³ The flap should be planned prior to other neck surgery when the vasculature remains intact. Detailed consideration and planning is mandatory prior to placement of the neck incisions to provide for harvest and closure of the flap and donor site region. The major advantage of the flap is that it can be harvested near the field of a cancer resection, and it provides thin, mobile myocutaneous coverage for oral and pharyngeal defects. Although the flap is primarily supplied by the facial artery, it has been harvested successfully following ligation of this artery during radical neck dissection. Although most commonly applied to the oral cavity region, it has been used in numerous defects of the head and neck region.^{34–40}

The primary disadvantage is that there is a high rate of partial flap necrosis with venous congestion and epidermolysis. Although the skin paddle often has partial necrosis, there is a low fistula rate when used for mucosal coverage.⁴¹

The flap technique requires that the distal flap incision be performed initially with a subplatysmal flap elevation, taking care not to injure the arterial and venous branches from the facial vessels. The proximal incision around the elliptical cutaneous paddle in the lower neck is elevated in a supraplatysmal plane, leaving an intact layer of platysma into the paddle. Modifications of this technique have been described that provide alternatives to flap harvest and reconstruction for appropriate defects.^{42,43} The flap is not usually the technique of choice when previous neck dissection or neck irradiation has been performed.⁴¹

SUBMENTAL FLAP

The submental flap is discussed in this section on regional pedicled flaps due to its potential for application in head and neck cancer reconstruction and because it is an axial flap based on the submental artery and vein. The flap has been reported to have a wide variety of uses in the head and neck region, including use in the oral cavity, lip, maxillofacial region, cervical esophagus, and for hemilaryngectomy defects.^{44–47} Anatomic studies have confirmed the vascular supply and caliber of vessels available for utility in adjacent regions.^{48–50}

The flap can be harvested as a myocutaneous flap to include the digastric muscle or as a fascial or fasciocutaneous flap. It has the obvious advantage of being convenient to the head and neck region with excellent color match. The scar is usually hidden inferior to the mandible and provides an improved cervicomental angle in most cases. The major argument against the use of this flap is that inadvertent harvesting of lymphatics of level IA during the flap harvest may compromise lymphadenectomy and allow for locoregional recurrence in squamous cell carcinoma. In these cases, a thinned flap is practical to prevent the inclusion of lymphatics in the flap.

OTHER FLAPS

Many other local and regional pedicled flaps are used for coverage of defects of the head and neck, including nasolabial, cervical, cervicofacial, superficial temporoparietal fascia, forehead, and chest wall flaps, but a detailed review of all flaps is beyond the scope of this chapter.

FREE TISSUE TRANSFER

Head and neck reconstruction cannot be described in the 21st century without including free tissue transfer as an integral component in the current standard of care for various traumatic, oncologic, and congenital defects of the head and neck region. Few would disagree that free flaps have resulted in improved functional and cosmetic results of many head and neck defects, particularly the anterior mandible. It is important to understand that the reconstructive option for a particular defect is not a decision between a “free flap” or a “regional flap” or “primary closure”; instead it is a consideration of which individual flap, technique, or combination of procedures will afford the patient the optimal survival, quality of life, and cosmetic result. One of the obvious advantages of free tissue transfer is that it enables the surgeon to choose from a variety of tissues and flaps, thus tailoring the procedure to the patient. For example, flaps can be harvested with a variety of quantities and qualities of skin, fascia, adipose, muscle, and bone, and some advanced techniques allow neural input or motor input to provide sensate and motorized flaps for particular defects. Free tissue transfer requires a dedicated team of surgeons to successfully coordinate the extirpative procedure with the reconstruction, which often encompasses preparation of the donor site, recipient vessels, and inset/pedicle geometry planning. Preoperative evaluation not only mandates a detailed history to assess prior trauma, surgery, or peripheral vascular disease, but also may require Doppler examinations, x-rays, or arteriography prior to flap harvest to determine the potential application of a particular donor site.

The flap failure rates for free tissue transfer continues to decrease with rates >95% despite such factors as exposure

to mucosal sites, contamination, radiated tissues, and elderly patients. This may be attributed to an increase in the number and quality of centers with additional training dedicated to these techniques.^{51–56}

Postsurgical monitoring and medical management of free tissue transfers remain controversial but include the use of a wide range of monitoring protocols and devices to assess clinical indicators such as flap color, temperature, texture, bleeding, and technologic advances including implantable and color Doppler.

This section reviews each of the more commonly used free tissue transfers for the head and neck region and discusses the technical considerations involving harvest and inset of the more commonly used flaps. The text is organized by flap rather than by defect, thus allowing the reader to focus on the issues surrounding each individual flap. The most common flaps used in the head and neck region are listed in Table 3–2.

PREOPERATIVE CONSIDERATIONS

The analysis of the recipient site should address the type of tissues lost, functional needs, cosmetic issues, and availability of donor vessels of sufficient caliber and length, therefore directing the surgeon to the most applicable donor tissue. The patient's occupation, avocations, and medical history along with the donor site morbidity further guide the surgeon to the best possible donor flap available.^{51,54}

Although there are no general contraindications to free flaps, prior surgery and medical problems in specific areas may provide a contraindication to specific sites. Medical problems such as poor nutrition, diabetes, and coagulopathy may provide relative contraindications to certain procedures.

TIMING

Most head and neck free tissue transfers are performed primarily at the time of oncologic resection to provide separation from contaminated cavities, protection of vascular structures, and immediate functional rehabilitation.⁵⁷ Secondary reconstruction in these cases often results in increased complications, scarring, nerve injury, and difficulty in the approach and inset. Functional outcomes have also been shown to be poor following delayed reconstruction.^{58–60} In traumatic injuries and revision reconstructions, delayed reconstruction may provide an opportunity for improved outcomes after wounds have healed.⁶¹ Surgery and reconstruction following chemotherapy or radiation therapy add complexity and concerns when choosing free tissue transfer versus regional flap reconstruction.⁶² When additional reconstruction or secondary free flaps are necessary for recurrent cancer, postchemoradiotherapy, failed free flaps, or cosmetic/functional indications, additional problems including approach, and microvascular

anastomotic, donor, and recipient site issues must be addressed.^{25,59,60,62–65}

OTHER POSITIONING

General inhalational anesthesia may be given via tracheotomy or orotracheal or nasotracheal intubation depending on the postoperative expectations for the patient's function and edema. A beanbag, axillary roll, and arm rest may be necessary in the patient undergoing scapula, trapezius, or latissimus flap harvest. The author suggests that the anesthesiologist be positioned at the foot of the bed, which then allows adequate surgical exposure to the flap harvest and head and neck region with the operative microscope in place. The two-team approach should be considered to decrease operative time and improve patient outcome when possible.

INTRAOPERATIVE CONSIDERATIONS

The care provided to the head and neck free flap patient from admission to the hospital through discharge requires extensive communication and attention to detail. The staff in the preoperative holding area should be knowledgeable about the planned procedure to prevent accidental needle sticks, intravenous line placement, or arterial line placement in the planned donor site region.⁶⁶ Patient position is dependent on the location of the flap and coordination of the procedure among the extirpative and reconstructive team regarding timing of each portion of the procedure. The position for harvest of flaps is discussed below. Coordination with the anesthesiologist should allow for timely administration of medications, the prevention of hypotension and hypothermia, and the use of various vasoconstricting agents during the procedure.

INTRAOPERATIVE MEDICATIONS

A variety of intravenous and topical agents have been advocated to improve flap viability, although widespread acceptance of any of these medications has not been achieved. Intravenous medications commonly include dextran, antibiotics, heparin, and in some cases steroids to reduce edema. Topical solutions and irrigants for use within and around the vascular pedicle and anastomosis have been advocated by many surgeons and include plain lidocaine or papaverine for improve vasodilation and prevention of vasospasm, and heparinized saline or lactated Ringer's for irrigation.^{67,68}

In certain situations, thrombolytic therapy including the use of streptokinase or urokinase^{69,70} may be considered to prevent microvascular thrombosis.^{71–74}

ANASTOMOTIC ISSUES

Meticulous technique using fine microvascular instrumentations and 9-0 or 10-0 nylon suture is the common

TABLE 3-2 MICROVASCULAR FREE FLAPS USED IN HEAD AND NECK RECONSTRUCTION

<i>Flap</i>	<i>Arterial Supply</i>	<i>Venous Outflow</i>	<i>Nerve</i>	<i>Tissue</i>	<i>Advantages</i>	<i>Disadvantages</i>
Radial	Radial	Superficial system: distal cephalic and basilic veins Deep system: paired venae comitantes of radial artery	Medial and lateral ante-brachial cutaneous	S, F, A, Ms, B, Se, Mo, palmaris longus tendon, optional bone (<40% of radius, optional)	Thin, pliable skin Simple two-team harvest Long pedicle Sensate potential Potential for tubing	Donor-site scar, sensory deficit, range of motion, strength Limited bone potential (ORFFF) Fracture (ORFFF)
Fibula	Peroneal	Paired venae comitantes	Lateral cutaneous nerve of the leg	S, F, A, Ms, B, Se	Excellent bone stock Sensate potential Simple two-team approach	Limited mobility of skin from bone, single skin paddle
Rectus	Deep inferior epigastric	Deep inferior epigastric	Segmental sensorimotor branches	S, F, A, Ms, Se, Mo	Large amount of thick tissue, can be perforator flap, potential motor function	Difficult in obese patients, potential for hernia
Latissimus dorsi	Thoracodorsal	Thoracodorsal	Thoracodorsal	S, F, A, Ms, Mo	Broad, thin flap with potential motor function	Requires lateral decubitus position
Scapula	Circumflex scapula	Venae comitantes	—	S, F, A, Ms, B	Multiple flap options from single pedicle Excellent 3-dimensional inseting Rare peripheral vascular disease	Positioning
Platysma	Facial	Facial External jugular	Cervical	S, F, Ms, Mo	Thin skin with potential for motor function	Contraindicated in prior neck dissection or radiation, skin unreliable
Gracilis	Profunda femoris	Paired venae comitantes	Anterior obturator	Ms, Mo	Excellent motor potential	Difficult harvest
Iliac	Deep circumflex iliac	Superficial inferior epigastric	—	S, F, A, Ms, B	Large bone stock with skin and muscle	Difficult harvest, donor site pain
Lateral arm	Posterior radial collateral	Venae comitantes	Posterior cutaneous nerve of the arm	S, F, A, Se	Excellent alternative to radial forearm Moderate thickness	Short pedicle, limited size
Lateral thigh	Profunda femoris	Venae comitantes	Lateral femoral cutaneous nerve	S, F, A, Ms, Se, Mo	Large amount of skin Two-team approach	Difficult harvest
Gastro-omental	Right gastroepiploic	Gastroepiploic	—	Mc, O	Excellent for skull base, mucosal defects Large amount of tissue	Requires additional donor site morbidity
Jejunum	Jejunal	Jejunal	—	Mc	Excellent for circumferential, mucosal defects	Requires additional donor site morbidity, delay in return of GI function

S, skin; F, fascia; A, adipose; Ms, muscle; B, bone; Mc, mucosa; S(e), sensate; Mo, motorized; O, omentum; GI, gastrointestinal; ORFFF, osteocutaneous radial forearm flap.

approach to microvascular anastomosis, although some authors now recommend the use of microvascular couplers for appropriate venous anastomosis.^{75–77} Preoperative understanding of the recipient and donor vascular anatomy, geometry, and size results in a pedicle with similar size match, tension-free geometric placement, and controlled anastomotic technique. The anastomosis is performed with running or interrupted suture in most instances, although a variety of technical modifications including the use of fibrin glue have been advocated.^{74,78–82}

Meticulous techniques in handling of the vessels and branches while avoiding intimal injury allows for a higher success rate. Flap ischemia time should be minimized whenever possible, although studies have yet to confirm a maximum ischemia time for head and neck free flaps; a maximum 3-hour ischemia time is the goal for many surgeons.^{83,84} The timing and order of the anastomosis and inseting varies as some surgeons prefer to complete the anastomosis prior to inseting to decrease ischemia time, whereas others inset the flap initially, hoping to prevent manipulation and trauma to the anastomosis during the inseting. Consideration should be given to both options depending on the situation during the procedure. The author prefers to inset those flaps that require considerable movement during inseting such as osseous flaps and tubed forearm and jejunal flaps prior to completing the anastomosis. However, flaps that do not require excessive manipulation are usually secured to the recipient site or tunneled into position but not inset until the anastomosis is completed. Following completion of the procedure, suction drainage should be secured well away from the vessels to avoid trauma during patient movement.

POSTOPERATIVE CARE

Postoperative care should include close monitoring by the nursing staff to ensure a warm room, adequate oxygenation, positioning, and patient comfort. It is common to elevate the head of the bed to 30 degrees to prevent venous congestion. In hypotensive states, inflow problems may be more common, during which the head should be lowered to provide improved blood supply.

MONITORING

The survival rate of free tissue transfer has continued to improve over the past few decades, raising the issue of the necessity for close monitoring of all free tissue transfers. These high success rates are reported commonly from well-trained, experienced microvascular surgeons, emphasizing the importance of experience and technique.⁸⁵ However, it is well known that in the small percentage of flap failures or thrombotic events, early recognition of the problem can prevent flap loss.^{51,54,86}

The vast majority of flap failures and thromboses occur within the first 48 hours of surgery, and evidence suggests that bone containing flaps and flaps requiring vein grafts have a higher failure rate.^{86–88} Those flaps that develop signs of failure with thrombosis are most commonly due to a venous problem.⁸⁸ There is no substitute for the meticulous technique in the handling of the vascular pedicle during harvest, transfer, inseting, and anastomosis. This section discusses important variables that should be considered in the perioperative care of patients undergoing free tissue transfer to prevent flap loss. The primary variables that may be used in flap monitoring all are directly or indirectly dependent on perfusion, including temperature, oxygenation, arterial supply, venous outflow, nutrition, and thrombotic events.

Prior to surgery, it is important to identify any past medical problems that may be related to the potential for a hypotensive episode, coagulopathy, thrombosis, infection, low oxygenation, or vasospasm.

A wide variety of monitoring techniques are presently in use and vary by surgeon and by specialty but include designing a “monitor” paddle, visual examination for color, continuous temperature and oxygen monitoring, laser and ultrasound Doppler scanning, photo and digital plethysmography, radioisotope clearance assays, and fluorescein perfusion monitoring.^{86,89–96}

Regardless of the techniques used to monitor free flaps, the location of the recipient site flap, inseting issues, pedicle geometry, and tissue characteristics all play a role in determine the ideal type of monitoring.

VISUAL EXAMINATION

When flaps with a cutaneous or mucosal component are used, visual examination may be the best and most cost-efficient method to monitor the flap viability. Additionally, training nurses and physicians to identify early problems often requires that they have extensive experience to recognize subtle changes during visual inspection. The flap color is typically the same as the donor site from which it was harvested and may be paler or darker than the surrounding tissue at the recipient site. A change in color is important to note, as this may be the first sign of an arterial or venous problem. Capillary refill should be assessed and documented, with each examination noting any change or regional differences in the flap. Temperature, color, skin turgor, and texture of the flap often give early signs when a problem may arise. An arterial problem is often manifested by pale color, slow capillary refill, decreased thickness or decreased edema, poor skin turgor, softening, cool temperature and lack of bleeding when punctured with a 20-gauge needle. A venous outflow problem can be identified when the flap appears red, blue, or purple with brisk or immediate capillary refill, increased edema and firmness, and dark blood when punctured. When using

surface Doppler assessment, it is important to consider adjacent or deep vessels, which may be transmitted through a thin flap to the Doppler, providing a false-positive examination for blood flow. Any change in surrounding tissues such as hematoma, wound dehiscence, salivary drainage, or infection should alert the surgeon that open exploration may be indicated.

BURIED FLAPS

Buried flaps represent a challenge for postoperative monitoring that has been addressed in a variety of methods by surgeons.^{54,91,92,97-99} When a flap is buried such as a jejunal flap, tubed radial forearm flap, or osseous flap without a skin paddle, assessment is often difficult and unreliable. If the flap is in the oropharynx, examination may be performed to view the flap. Otherwise, a natural external tissue "monitor" may be brought out into the skin to allow a way to directly monitor the flap. If this is not possible, direct monitoring through a buried probe may be helpful. When a problem is considered, early exploration for thrombosis is particularly useful to prevent complete flap loss.

FLAP THROMBOSIS AND SALVAGE

Although some surgeons do not monitor flaps closely due to greater than 95% flap success, those cases that are recognized within 4 to 6 hours following the onset of thrombosis have a 69% salvage rate when appropriate revision is performed.⁵⁵ Studies have revealed venous thrombosis to be more common than either arterial or combined arterial and venous thrombosis. Over 75% of flap thromboses have occurred within the first 48 hours following completion of the procedure.⁸⁶⁻⁸⁸ Once the thrombosis is recognized, the patient should first have a complete evaluation to rule out nontechnical etiologies such as positioning, temperature, blood pressure, and hematoma. Correcting these problems at the bedside is done immediately while the operating room and personnel are alerted about the planned transfer to surgery. Medical therapies for the prevention and treatment of thrombotic events during free flap transfers often depend on surgeon preference, although some studies have revealed success with any one of a variety of protocols.^{55,69,71-73,100-103}

The patient is usually administered intravenous heparin at 5000 U, and the neck is explored with gentle irrigation to view the vascular pedicle. Doppler examination of all arterial and venous structures should aid in the localization of the problem. Commonly, a venous thrombosis is identified, and this anastomosis is resected with fine microscissors, allowing decompression of the venous congestion. Often, the arterial flow then clears much of the thrombus, although any remaining thrombus may require clearing with a No. 2 or 3 Fogarty catheter. If further arterial problems are identified, the arterial anastomosis and inflow should be taken down to

analyze the location or extent of thrombus. If necessary, arterial irrigation with streptokinase or urokinase at a dose of 50,000 to 100,000 U is performed. If another recipient artery is necessary, this dissection is performed, and if added length is required for the artery or vein, a saphenous vein graft is harvested. Confirmation of flow through the system is confirmed with heparinized saline irrigation using a 20-gauge angiocatheter. We withhold the use of leech therapy unless we have confirmed adequate arterial inflow but poor venous outflow. Complete venous obstruction mandates microvascular revision when possible, whereas partial venous congestion may be successfully treated in certain instances by leech therapy.^{72,104-109} The mechanism of action of leeches is based on the agent hirudin, a selective thrombin inhibitor and potent anticoagulant.¹¹⁰ It is important to use prophylactic antibiotics due to the transmission of *Aeromonas hydrophila* by some leeches.^{105,108} When leeches are used in the head and neck, an adhesive covering is placed around the flap to prevent leeches from moving to other sites and constant nursing care is necessary to prevent movement into the pharynx or tracheotomy.

RADIAL FOREARM FASCIOCUTANEOUS FLAP

The utility and application of the radial forearm fasciocutaneous free flap in the head and neck has continued to increase since its introduction in the late 1970s.¹¹¹⁻¹¹⁴ Its use was popularized by Soutar in the early 1980s, including the use of the osteocutaneous extension of this flap.¹¹³⁻¹¹⁷

It has wide application in the head and neck region, particularly in the aerodigestive tract. It has become the workhorse flap for head and neck reconstruction, and it is utilized more than any other single flap in two large retrospective reviews.^{52,118} Other authors have considered the lateral thigh flap to provide similar coverage of soft tissue defects.^{119,120} The ulnar artery-based forearm flap also is used by several surgeons with successful results for similar recipient site defects.¹²¹⁻¹²³

Indications

The radial forearm flap is one of the most commonly used free flaps in head and neck reconstruction, particularly in the oral cavity, oropharynx, hypopharynx, and esophagus. The potential addition of bone provides anatomic reconstruction of areas requiring thin bone such as the ascending ramus of the mandible, alveolar arches, orbital rim, and zygomatic arch. The most common use of the radial forearm flap is in the oral cavity and pharynx, although it has enjoyed widespread use throughout the head and neck region including the skull base, trachea, partial laryngectomy defects, and maxillofacial defects.¹²⁴⁻¹³²

The radial forearm fasciocutaneous flap is ideally suited for partial to near-total glossectomy defects due to the

thin, pliable, sensate skin covering. The flap usually mucosalizes over a period of 3 to 12 months, making it difficult to differentiate from surrounding tongue surface, and it also may regenerate sensate potential with or sometimes without nerve grafting.^{124,133,134} It can provide vascularized covering to most soft tissue defects of the oral cavity including total upper or lower lip defects, which can incorporate the palmaris longus tendon for lip suspension. It remains our flap of choice for large oropharyngeal defects, which include the pharyngeal wall, tongue, or soft palate due to the three-dimensional shaping required for these areas and its sensate potential. Its use in oromandibular reconstruction with lower donor site morbidity than initially reported may provide a benefit over other reconstructive options when osseointegrated implants are not indicated.^{135–139} Another common use is in total pharyngoesophageal defects for which it is useful as an alternative to the jejunal free flap.^{97,140–142} The ability to tube the radial forearm flap while in situ in the forearm can also decrease ischemia time.

Anatomic Considerations

As in all flaps to be discussed, the anatomy of the region should be studied by the surgeon in detail in anatomic textbooks, in cadaveric dissections, and by assisting in the harvest prior to undertaking free tissue harvest. Knowledge about the vascular structures proximal and distal to this area is important in assessing options for harvest and flow requirements for the flap. The radial forearm flap is based on the radial artery, which arises from the brachial artery near the antecubital fossa. The ulnar artery also arises in this region, and the relationship of the radial artery to the ulnar artery and radial recurrent artery is important during the harvest of both radial and ulnar-based flaps. Distally, the ulnar artery runs deep to the flexor carpi ulnaris but may be identified superficial in the distal forearm. The vessels usually communicate via the palmar arches in the hand, and if there is not a patent arch, the flap is contraindicated without a vascular graft. The skin, bone, and fascia of the flap are supplied via perforators easily identified during the dissection. The deep periosteal perforators extend through the flexor pollicis longus muscle to the radius. During the dissection, the anatomic location of the radial and ulnar arteries, superficial veins and vena comitantes, flexor carpi radialis, brachioradialis and palmaris longus tendons and muscles, and the radial and median nerves should be appreciated. During the harvest of bone, the insertion of the brachioradialis tendon is the distal extent of bone harvest.

Advantages and Disadvantages

The radial forearm flap has numerous advantages and few disadvantages, although in some patients the

disadvantages may outweigh the potential advantages. The flap is extremely reliable and has a consistent pedicle that is lengthy and of large caliber.^{52,143,144} It is thin and liable with sensate potential, adding to the benefit in individuals with expected return of swallowing function. It may be harvested by two teams and is easily contoured and shaped to a particular defect. It is well vascularized throughout its length, allowing for the use of split-paddle or even three-paddle skin coverage. The potential addition of bone provides anatomic reconstruction of areas requiring thin bone such as the ascending ramus of the mandible, alveolar arches, orbital rim, and zygomatic arch. The skin color match is fair at best in Caucasians but good to excellent in the non-Caucasian population. The donor site remains the major disadvantage of the use of this flap, although specialized techniques may improve on the unsightly scar and resulting morbidity of this site.^{145–147} If aggressive physical therapy is not instituted, limitation in range of motion of the wrist can occur due to scarring and fibrosis.

Preoperative Evaluation

The anatomic dissection of the soft tissue harvest of the radial and ulnar flaps overlaps considerably, so this discussion will focus on the neurovascular, soft tissue, and bony landmarks of the volar aspect of the distal half of the arm. Unlike many donor sites, the majority of the structures of the arm are readily visible or palpable prior to the surgical harvest. It is important to assess the skin of the entire arm from the shoulder to the tips of the fingers for prior surgical or vascular intervention. Any compromise of vascular flow, including prior blood draws and needle sticks, can interfere with the viability of flaps of this region. The gold standard test prior to harvest is Allen's test, which is performed to assess the patency of connection of the superficial and deep palmar arches in the hand.¹⁴⁸ The test is performed by asking the patient to firmly make a fist repeatedly while the examiner is simultaneously compressing the radial and ulnar arteries. After complete blanching of the hand is confirmed despite the patient's cessation of making a fist, the ulnar artery compression is released while firm pressure remains on the radial artery (thus duplicating the effect following ligation of the vessel). The return of blood flow to the digits, particularly the fourth and fifth, is assessed to visualize rapid (less than 5 seconds) return of flow, confirming patency of the two arches. If repeated tests indicate a problem with the patency, the other arm should be examined, and Doppler studies should be considered to fully evaluate the system prior to harvest. There have been rare cases of anomalous forearm vascular supply, which must be considered prior to the radial forearm harvest to prevent ischemia to the hand.^{143,149,150} The brachioradialis, flexor carpi radialis (FCR), palmaris longus, radial nerve, radial artery pulse, capillary refill,

antecubital fossa, and cephalic and basilic veins should all be examined and identified prior to the planned donor site harvest.

Techniques

Harvest

The arm should be free of intravenous or arterial lines and needle sticks. A second nursing and surgical team is necessary for the two-team approach. Prior to incisions, the arm is marked for important landmarks including the radial artery, superficial veins, and radial nerves. A tourniquet is applied to the upper arm but is not inflated until the arm is exsanguinated and the procedure is ready to begin. The arm is extended on an armboard, allowing the surgeons to sit opposite each other during the dissection. The thigh should be prepared or appropriate allograft material available for coverage of the donor site. The planned skin paddle is marked overlying the volar aspect of the forearm centered on the donor artery. A curvilinear incision extends to the antecubital fossa for extended length pedicle. When the necessary cutaneous paddle may be positioned away from the bone during the osteocutaneous transfer, the skin paddle may be located toward the ulnar aspect to facilitate three-dimensional mobility.

The skin and underlying fascia are then elevated from the radial aspect toward the ulnar aspect, identifying the distal radial nerve branches that may divide into two to five small branches at the wrist. Care is taken to divide the fascia at the brachioradialis and dissect deep to the vascular pedicle, preventing separation of the cutaneous paddle if dissection occurs superficially. After the pedicle is identified, the venous branches of the superficial and deep system are ligated, leaving the radial artery flowing distally beyond the flap. The dissection is then started from the ulnar aspect and elevated toward the pedicle, taking care to remain superficial to the ulnar artery and median nerve. Important points to remember during the harvest are to preserve the paratenon fascia overlying the tendons of the flexor carpi radialis, palmaris longus, and brachioradialis muscles to prevent tendon exposure. The dissection then proceeds deeper when the lateral edge of the FCR is identified, taking care to identify the deep perforating branches to the periosteum of the radius. The deep osseous branches are ligated when bone is not harvested and carefully preserved when an osteocutaneous flap is harvested. The distal and proximal incisions are connected around the periphery of the flap, leaving the flap connected proximally through the neurovascular attachments and by the radial artery distally. The cutaneous nerves are immediately deep to the

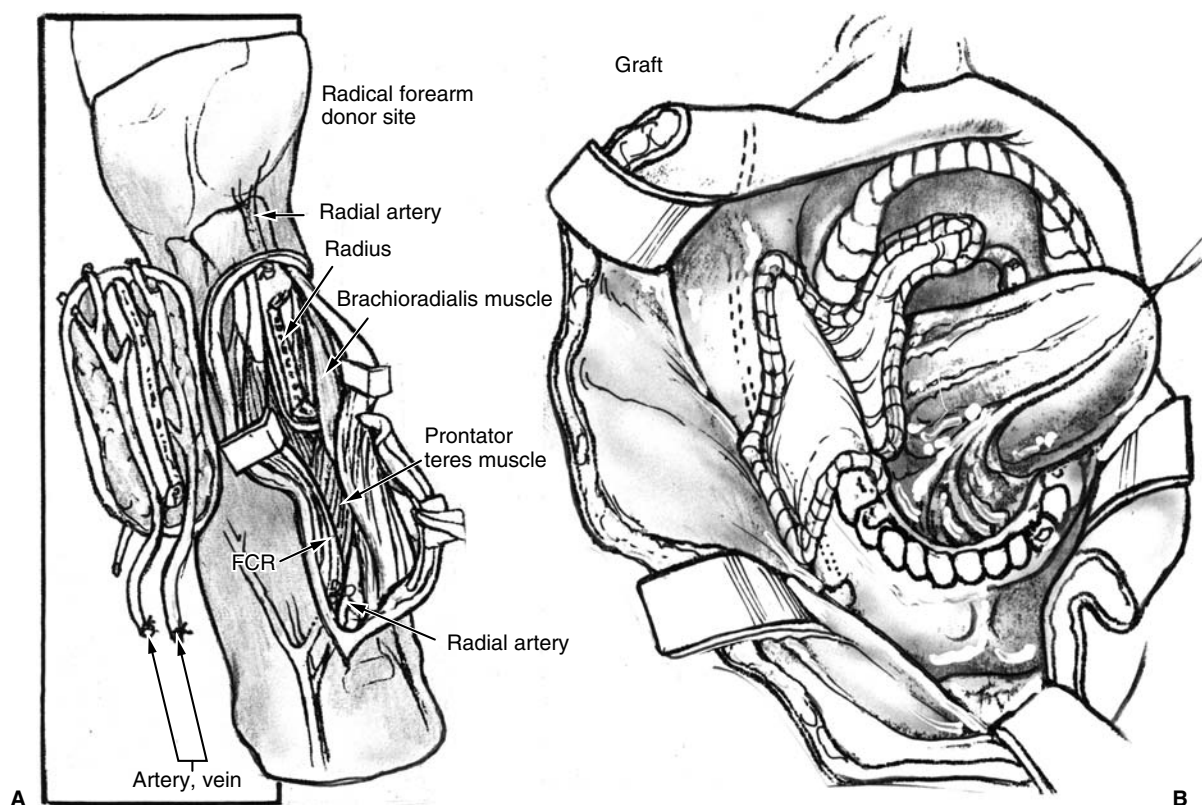


FIGURE 3-3 Radial forearm osteofasciocutaneous free flap. (A) Illustration of the donor site flap elevation. (B) Insetting of the radial forearm fasciocutaneous free flap for defect of the lateral mandibular and oropharyngeal soft tissue defect.

subcutaneous tissue proximally and should be preserved when possible. These nerves usually run alongside the distal branches of the superficial venous system. At this point, separation of the brachioradialis and FCR allows visualization of the proximal radial artery and paired venae comitantes to the antecubital fossa. The deep and superficial systems merge into a plexus of veins in the antecubital fossa and beyond, often allowing the surgeon to perform fewer venous anastomoses but allowing flow through both systems.

This section describes variations that apply exclusively to the osteocutaneous flap harvest (Fig. 3-3).

The flexor digitorum superficialis (FDS) must then be separated from the radius distally to provide exposure to divide the flexor pollicis longus (FPL) and periosteum of the medial aspect of the radius. It is recommended that less than 40% of the diameter of the radius be harvested, and the length should be limited to the bone distal to the insertion of the pronator teres and proximal to the insertion of the brachioradialis. Studies have supported the use of internal rigid fixation to prevent radius fracture and improve the strength of the remaining radius, thus requiring preservation of a segment of distal radius for screw fixation. The bone is exposed along the length of the harvest site, and after elevating the periosteum at the planned osteotomy sites, the oscillating saw is used to divide the partial-thickness proximally and distally. The osteotomy along the length of the radius is then performed carefully to avoid overresection. The flap is ready for transfer. After transfer, hemostasis is obtained and the plating of the radius is performed under fluoroscopic confirmation of plate placement. The procedure is completed as described in the standard fasciocutaneous technique.

The distal radial artery is then clamped with a temporary clamp while the tourniquet is released, confirming flow to the digits through the palmar arches. It is then safe to ligate the distal radial artery and transfer the flap when the recipient site is prepared. The forearm should be closed with a split-thickness skin graft, although a recent study suggests that allograft material may be a suitable replacement.¹⁵¹ A prefabricated forearm splint is placed to secure the graft material for 7 days, and monitoring of the vascular supply to the hand continues throughout the postoperative period.

The most common complications following radial forearm flap harvest include skin graft loss, sensory deficits, and cold intolerance and motor strength deficits of the hand.¹⁵²⁻¹⁵⁵ The paratenon fascia preservation overlying the tendons cannot be overemphasized, as this is the enveloping fascia that allows vascular ingrowth from adjacent tissues and grafts.¹⁵⁶ When this is removed, it is helpful to advance adjacent muscle or adipose to cover any exposed tendon prior to grafting.

Physical therapy with wrist and hand range-of-motion exercises should commence within weeks

following the procedure to ensure adequate motor function.

The three to five small, superficial branches of the radial nerve should be identified early in the dissection to prevent accidental transection or trauma and permanent numbness, although some patients do have resultant sensory loss when these branches are preserved.¹⁵⁴

The contraindications to the radial forearm flap include generalized coagulopathic states and other medical conditions that prevent all free tissue transfers. The unique contraindications include anomalous palmar arch anatomy, radial or ulnar agenesis or thrombosis, and prior surgery or trauma to the forearm area. Patient function, occupation, and avocation may preclude the use of this donor site. The flap has been successfully transferred by the author in patients with connective tissue disorders and graft-versus-host disease.

CONTROVERSY

Preoperative evaluation has been discussed by various authors and has consisted of Allen's test alone, preoperative Doppler assessment, or intraoperative monitoring with assessment of distal flow to the digits.^{143,148-150,157} The author recommends Allen's test in all patients and Doppler assessment in those with an equivocal Allen's test or prior arterial line placement. Post-harvest grafting techniques have included split-thickness skin graft, dermal graft, purse-string with grafting, local flaps, and allograft materials.¹⁵¹ Controversy exists about the use and technique of various flap and graft materials including the prefabricated fascial radial forearm free flap to preserve donor site cosmesis and tendon coverage.¹⁵⁸⁻¹⁶⁰

The use of the osteocutaneous radial forearm flap has not gained wide acceptance due to early reports of increased donor site morbidity including fracture of the radius. The lack of adequate bone for osseointegrated implants is a second reason for its limited use in mandible reconstruction, although limited donor morbidity and reduced fracture rate have been reported.^{135,136}

FIBULA OSTEOCUTANEOUS FREE FLAP

The fibula free flap has become the gold standard for reconstructive procedures of large mandibular defects owing to its excellent bone stock, skin paddle availability, sensory potential, and acceptance of osseointegrated implants. Initially described by Taylor, it was applied to the mandible and popularized by Hidalgo and others for head and neck reconstruction.¹⁶¹⁻¹⁶⁵ The early application of the

fibula osteocutaneous flap revealed a high failure of the cutaneous paddle due to variations in the septocutaneous and musculocutaneous perforators and the early loss of the skin paddle during mandibular reconstruction. The flap has since been introduced with a variety of modifications using osteotomies and sensory innervation and applied to numerous regions of the head and neck.^{90,165–169}

Indications

The fibula free flap is most commonly used as an osteocutaneous free tissue transfer that is ideal for reconstructing oromandibular defects, although utility in the orbitomaxillary regions has also been successful. It is the flap of choice in composite segmental oromandibular defects of the anterolateral mandible with soft tissue loss when osseointegrated implants or sensory innervation would benefit the patient. It is also useful in reconstructing oromaxillary and orbitomaxillary defects, providing excellent bone stock, which permits osteotomies for accurate contouring and inseting.^{170,171} It is particularly useful in patients who are candidates for osseointegrated implant-directed dental or maxillofacial rehabilitation.¹⁷¹ The skin paddle is dependent on septocutaneous and myocutaneous perforators and provides adequate coverage for mucosal or skin reconstruction. The proximity of the skin paddle to the bone and limitations in perforators result in a skin paddle that may not always be suitable for dual-paddle, through-and-through defects. It is not ideally suited for tongue reconstruction because of the limited range of motion of the skin paddle relative to bone and the thickness of the skin paddle. In cases of complete hemimandibular defects, the most distal bone can be contoured and covered with adjacent de-epithelialized fascia and fat to provide an articulating condyle with maintenance of masticatory ability.

This flap is contraindicated in patients with severe peripheral vascular disease, diabetic neuropathy, anomalous vascular anatomy preventing three-vessel runoff to the foot, lower extremity weakness or paralysis, and prior surgery or trauma to the lower leg or aortoiliac system.

Anatomic Considerations

The lower leg anatomy, compartments, and musculoskeletal function must be well understood by the reconstructive surgeon. Evaluation of the popliteal, peroneal, posterior tibialis, and anterior tibialis arteries may be required preoperatively with arteriogram or magnetic resonance angiography, to help prepare the surgeon for variations and atherosclerotic disease. These studies not only can confirm the adequate blood supply to the foot through the posterior tibialis and anterior tibialis, but also can assist the surgeon in planning the skin paddle based on the septo- and musculocutaneous perforators, and in determining the location and length of the vascular pedicle relative to these branches. The posterior trunk of the popliteal artery branches to form the posterior tibialis and peroneal arteries. The peroneal separates from the

posterior tibialis artery to course alongside the fibula, sending endosteal and periosteal branches throughout the course of the fibula. The pedicle length ranges from 3 to 8 cm, the arterial diameter ranges from 2.0 to 3.5 mm, and the venous diameter ranges from 2.5 to 4.0 mm. The location and relationship of the anterior and posterior tibialis muscles, flexor hallucis longus (FHL), peroneus longus, soleus, and gastrocnemius are important in planning the exposure and position of the skin flap and pedicle. The peroneal nerve crosses the fibula ~3 cm distal to the proximal femoral head, and for this reason and for the stability of the knee joint, 4 to 6 cm of proximal fibula should be preserved. The lateral sural cutaneous nerve to the leg requires identification prior to dividing the subcutaneous and fascia layers during the harvest, and may be preserved when sensate flaps are necessary. The skin paddle is commonly supplied by branches of this nerve, whereas the vascular supply to the skin is provided by perforating vessels that course through and within the posterior crural septum between the peroneus longus and soleus muscles. Musculocutaneous perforators track through the soleus muscle and should be preserved to optimize supply to the cutaneous paddle. The majority of perforators have been identified to branch in the lower two thirds of the lower leg, requiring placement of the skin paddle in this region.

Advantages and Disadvantages

The fibula free flap has several advantages over other osseous and osteocutaneous flaps, including the ease of two surgical teams working simultaneously. Other advantages include the large bone stock to support osseointegrated implants, the adjacent sensate skin paddle for reconstructing intraoral mucosal defects, and the long length of bone (up to 25 cm) available for multiple osteotomies if necessary. The fibula bone can be shaped to replicate most bony contours of the mandible and maxilla with long-term preservation of bone height, allowing for delayed placement of osseointegrated implants.¹⁶⁷ Donor site morbidity commonly relates to sensorimotor changes and wound problems in the lower leg and ankle.¹⁷² The primary disadvantage of the flap tissues relates to limited skin paddle mobility, preventing mobile tongue reconstruction and soft tissue filling beyond the site of the bone defect. The pedicle length may be limited by the location of the posterior tibial artery, bone harvest, and perforator vessels. The donor site defect often requires a split-thickness skin graft for coverage of the depressed area in the lower leg. Donor site complications have been shown to be increased in patients with a history of heavy smoking, whereas overall donor site complications range from 0 to 30%.¹⁷³ Complications from fibula harvest include wound dehiscence, muscle necrosis, skin graft loss, distal sensory deficits, motor deficits including weakness in dorsiflexion of the foot and ankle, chronic pain, persistent edema, and cold intolerance.^{173–180} Complications related to the inseting and recipient site include vascular thrombosis, skin

paddle loss, malunion, osteoradionecrosis, plate exposure, and trismus.^{64,162,168,181–183}

Preoperative Evaluation

The evaluation prior to harvest of a fibula free flap requires detailed examination of the lower extremities including skin, distal pulses, motor function, and sensation. Prior surgical scars, weakness, and neurologic abnormalities must be noted. Although vascular studies are controversial, most reports encourage testing in addition to physical examination to select the side of harvest and to confirm adequate vascular supply.^{178,184,185} This may include Doppler examination, magnetic resonance angiography, or arteriography.^{186–188}

Techniques

Harvest (Fig. 3–4)

The initial positioning of the patient during the fibula harvest is important in facilitating the dissection. The patient should be placed supine with a soft leg cushion support beneath the thigh, resulting in knee flexion and internal rotation of the lower leg. The thigh is prepped into the field allowing for preoperative or intraoperative placement of the tourniquet and for skin graft harvest if indicated. The heel should be padded and the lower leg shaved circumferentially. The author recommends placing the tourniquet at the time of commencement of the harvest and removing it upon completion to avoid inadvertent reinflation and allow for skin graft harvest.

The hand-held Doppler can be used to locate the septo/musculocutaneous perforators, providing a template for placement of the skin paddle. Otherwise, the paddle should be centered longitudinally along the posterior border of the fibula. The anterior pedicle exposure is discussed here, although posterior dissection and pedicle identification is an alternate technique used by many surgeons.

The incision is performed through the skin, subcutaneous tissue, and fascia overlying the soleus and anterior tibialis muscles. Extension from the head of the fibula to the lateral malleolus allows wide exposure. Care is taken to avoid division of the superficial peroneal nerve coursing over the fibula. The cutaneous nerve branch to the skin paddle can be identified in this location and dissected into the flap, providing sensory input if available.

The peroneus longus muscle and tendon are identified and retracted anteriorly to expose the lateral flat edge of the fibula. Dissection anteriorly around the fibula provides exposure of the intermuscular septum and interosseous membrane, which are divided, exposing the peroneal vascular pedicle.

The anterior tibial artery and deep peroneal nerve may be encountered and should be avoided and protected. To enhance exposure and protection of the vascular pedicle, the author recommends division of the bone proximally and distally. A curved, J-shaped elevator allows

subperiosteal dissection around the pedicle, preserving 6 to 8 cm of distal fibula proximal to the ankle. The right-angled hemostat provides placement of a small malleable retractor, protecting the pedicle from the sagittal saw used for the osteotomy. A similar dissection is performed proximally 6 to 8 cm distal to the knee. These two osteotomies provide 2 to 3 cm of lateral retraction of the bone and exposes the flexor hallucis longus and posterior tibialis muscles, furthering the dissection and exposure of the pedicle. The distal artery and two veins can be ligated. The muscles are divided from distal to proximal to the branching of the peroneal vessels with the posterior tibial vessels. The flap is pedicled only on the proximal soleus, which is separated from the fibula. The pedicle is dissected free of branches and prepared for division once the recipient site is completed. Following division of the pedicle and transfer for inseting, the periosteum can be elevated from the proximal bone that is not needed, lengthening the vascular pedicle. During the inseting, it is recommended that particular attention be paid to the relationship of the pedicle to the final bone location, septum placement around the bone flap, and tension placed on the skin paddle once in its final location. The author recommends rigid fixation of the fibula prior to microvascular anastomosis to prevent trauma to the pedicle during drilling and plating.

The donor site is closed with loose muscular sutures from the FHL to the intermuscular septum, and suction drain is placed. The split-thickness skin graft is then placed over the muscle and fascia layer and covered with wound dressings or wound vac. The leg is immobilized for 5 to 7 days before progression to ambulation and physical therapy.

CONTROVERSY

Early reports suggested limitations to the viability and use of the skin paddle associated with the fibula flap, although assessment of the perforator system has since revealed that this limitation in cutaneous supply appears to be uncommon.^{169,189} The primary controversies surrounding the fibula free flap include the preoperative evaluation and the type of closure. Although the reports agree that physical examination is essential, many authors do not rely solely on the exam and advocate arteriogram, magnetic resonance angiography, or Doppler evaluation of the lower leg vasculature,^{178,186,187,190–193} whereas others believe that a less invasive technique such as physical examination of the posterior tibial and dorsalis pedis pulses is adequate to determine the potential use of this donor site.^{185,194}

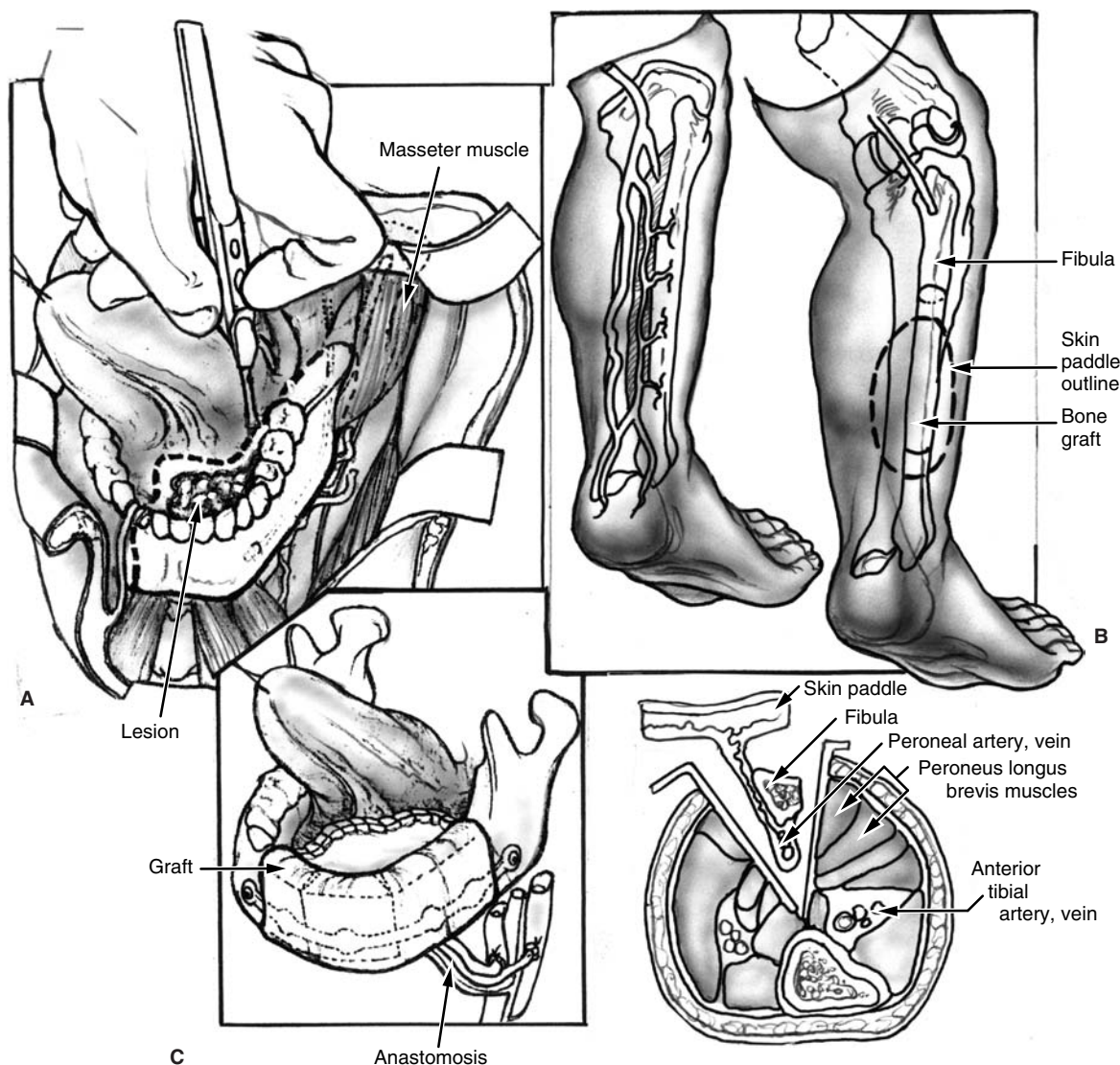


FIGURE 3-4 Fibula osteocutaneous free flap. (A) Common defect of the oral cavity, mandible, and floor of the mouth for which a fibula osteocutaneous free flap is indicated. (B) Anatomic view of the right lateral leg placement of skin paddle and cross-sectional view of harvested tissues in a fibula osteocutaneous free flap. (C) Inset of a fibula osteocutaneous free flap for an oromandibular defect with the transosseous reconstruction plate, bony osteotomies for contour, and skin paddle to cover the intraoral mucosal defect.

The type of closure of the donor site with primary closure versus grafting techniques varies among surgeons, although the goal should always be a tension-free closure.^{163,173,180,195,196}

RECTUS ABDOMINUS FREE FLAP

The rectus abdominis free flap (RAFF) has a variety of indications and applications in the head and neck including total glossectomy and oral cavity, maxillary, and soft tissue defects, although it may be most commonly applied to skull base defects. The flap includes varying thicknesses of skin, subcutaneous adipose, and muscle, and reported success with perforator flaps allows them to be customized to the individual defect.¹⁹⁷⁻²⁰¹ The

RAFF historically was used as a pedicled flap for breast and chest reconstruction, but the availability of large amounts of well-vascularized tissue with a large-caliber, long pedicle has enhanced its popularity for head and neck defects. It can be harvested via a two-team approach.²⁰² Studies also revealed a lower complication rate for the RAFF when compared with the pectoralis myocutaneous flap.²⁰³

Indications

The early use of the RAFF was limited to defects requiring large, thick soft tissue coverage, although the indications expanded to include total glossectomy and other oromaxillary and skull base defects.^{204,205} With advances in skull base surgery including orbitomaxillary

indications, its use expanded as one of the more popular reconstructive techniques, particularly in skull base wounds previously operated on or exposed to radiation therapy.^{132,206} The scapula fasciocutaneous flaps may provide excellent soft tissue coverage for parotid, facial, and neck defects.^{207,208}

Anatomic Considerations

The RAFF can be used as a myocutaneous, myofascial, or fasciocutaneous free flap, and the thickness of each layer of tissue varies with the individual. The muscle is supplied by both the superior and inferior epigastric arteries, whereas the more commonly used flap is supplied by the deep inferior epigastric artery and paired venae comitantes. The arterial supply ranges from 2.5 to 4 mm in diameter and is derived from the external iliac vessels and enters the muscle on its deep surface, terminating in numerous musculocutaneous perforators highly concentrated circumferentially around the umbilicus. The muscle is supplied by the lateral entering segmental sensorimotor branches, allowing for a potential neurotized flap for motor function and retention of muscle bulk. Measuring up to 40 cm in length and 10 cm wide, the rectus abdominis muscle extends from the pubic symphysis and crest to the fifth to seventh ribs. The muscle is surrounded by the superficial and deep muscular fascia, which is important in closure of the donor site defect and abdominal wall strength. It is imperative that the surgeon understand the multiple fascial layers of the abdominal wall and the preservation of fascial layers for abdominal support following harvest of these flaps. The anterior rectus fascia is composed of the internal and external oblique fascia layers. The internal oblique fascia splits lateral to the rectus muscle to envelope the muscle as both the anterior and posterior rectus fascia. The posterior rectus sheath is limited to the area superior to the arcuate line, which is approximately halfway between the umbilicus and pubic symphysis. Inferior to this line, the posterior rectus fascial covering is limited to the transversalis fascia.

Advantages and Disadvantages

The recent emergence of variations in the perforator flaps has allowed for additional indications and advantages of the rectus flaps, providing customized flaps for most soft tissue defects of the head and neck. Notable advantages of this flap include its reliability, ease of harvest, long pedicle of high caliber, and suitability for a two-team approach. Disadvantages of the flap include a poor color match for the head and neck, and excess bulk that may require future debulking procedures. When used as a myocutaneous flap for skin coverage in the skull base and orbitomaxillary region, there is a resultant gravitational displacement over time that may become unsightly. The flap is difficult to harvest in the obese

individual, and should be used with caution in patients with prior abdominal or inguinal surgery.

Preoperative Considerations

Prior to the harvest of a RAFF, the surgeon must review the past medical and surgical history, particularly related to any vascular, abdominal, pelvic, or hernia surgery. Although not an absolute contraindication, prior inguinal herniorrhaphy may have resulted in trauma or ligation of the inferior epigastric vessels. Physical examination should include evaluation of the femoral pulses, abdominal skin for prior scars, and body habitus related to the expected recipient site defect. Patients with prior surgery peripheral vascular disease may require arteriogram to confirm adequate flow through the iliac and deep inferior epigastric artery (DIEA).

Techniques

The abdomen is prepped and exposed bilaterally from the pubis to the chest, and the iliac vessels are marked after Doppler confirmation of their location. The flap can be oriented vertically along the long axis of the muscle or obliquely from the midline toward the lateral costal margin. The side of the defect and location of the planned microvascular anastomosis may help determine which side of the rectus harvest would result in the ideal inset and pedicle geometry in relation to the pedicle entry into the muscle and orientation of the skin paddle. For example, a right fronto-orbital skull base/forehead defect with planned right superficial temporal artery (STA) anastomosis would direct the surgeon to the left RAFF, providing the ideal pedicle location into the STA if the skin paddle was exteriorized. The flap skin pedicle should include the periumbilical region and associated perforators and can be oriented diagonally toward the lateral costal border or vertically toward the xiphoid. The planned incision is marked, and Doppler confirmation of pedicle location can also be used. The flap is incised circumferentially through the anterior rectus fascia to expose the rectus muscle. The fascia is secured to the dermis of the flap to avoid shearing during retraction. An inferior extension of the incision toward the pubis is completed overlying the center of the rectus muscle. Subcutaneous flaps are then elevated medially and laterally for exposure and for advancement flap closure. Dissection then proceeds from lateral to medial overlying the external oblique to identify and preserve the segmental nerve branches into the rectus muscle. These are divided, allowing elevation of the muscle from the posterior rectus fascia superior to the arcuate line and transversalis fascia inferior to this line. The pedicle is identified on the deep aspect of the muscle entering laterally. The muscle remains attached inferiorly and superiorly while the pedicle is skeletonized. The muscle can then be divided inferiorly, but release of the superior

border of the muscle can compromise exposure of the pedicle dissection. Once the pedicle is divided, the muscle is released superiorly. The flap is then ready for inseting and microvascular anastomosis.

Donor Site Closure

Meticulous closure and abdominal wall reconstruction is necessary to prevent herniation. The anterior rectus fascia is reapproximated from the pubic symphysis to the arcuate line followed by securing this layer to the posterior rectus fascia superior to the arcuate line. On occasion, the anterior rectus fascia surrounding the skin paddle can be partially closed to provide further strength to the abdominal wall. In the elderly patient or patients with connective tissue disorders or prior surgery, abdominal wall mesh reconstruction may be necessary.

CONTROVERSY

The utility of the RAFF in restoring tongue function including speech and swallowing has not been thoroughly evaluated, although reports do reveal this potential. In free flap reconstruction of oromaxillary and orbitomaxillary defects, the functional and cosmetic outcomes are often assessed in relationship to prosthetic reconstruction.^{171,209} The sensorimotor potential of this flap has been described for facial paralysis and tongue reconstruction, although confirmation of the success of this neurovascular potential in restoring cosmesis and function requires further evaluation.^{204,210–212}

SCAPULA/PARASCAPULA

The subscapular system of flaps was developed after a cutaneous flap based on the circumflex scapular artery (CSA) was used.^{213,214} This system has allowed wide variations and combinations of flaps, including the cutaneous flaps, osteocutaneous flaps, and a combination that may include the latissimus myocutaneous system in addition to the scapula flaps.^{215–217} The scapula flaps have provided many options as both primary and secondary flaps for the head and neck reconstructive procedures. Although it does provide adequate tissue for almost all defects, it does have limitations, and the patient positioning obviates a simple two-team approach.

Anatomic Considerations

The axillary and parascapular region is a complex area that is difficult to access. The scapular system of flaps may include a fascial flap, scapula/parascapula two-paddle skin

flap, osteocutaneous flap, and combination flaps including the latissimus myocutaneous flap. The scapula free flaps are supplied by the subscapular system, which branches into the circumflex scapular artery, angular artery, and the thoracodorsal artery, thus allowing for the harvest of skin, fascia, bone, and latissimus muscle when necessary. The subscapular artery extends up to 6 cm in length with a diameter averaging 4 mm.¹⁴ The bone stock of the scapula is not considered as thick as that of the iliac or fibula bone, making it less favorable for osseointegrated implants, although many do have adequate bone stock.^{166,218} The lateral border of the scapula is often included in the osteocutaneous flap, although the plate of the scapula may be only millimeters in thickness. The tip of the scapula bone is supplied separately by the angular artery, which may be preserved when extended bone length is necessary.²¹⁹ The teres minor and major muscles in addition to the deltoid and long head of the triceps muscle must be dissected from the flap for adequate pedicle exposure. The flap does not have sensate or motor potential unless the thoracodorsal nerve and latissimus muscle are harvested in conjunction with the scapula system.

Indications

The scapula flap is commonly used as the primary flap for two- or three-layer oromandibular defects. It is the flap of choice for three-layer defects including mucosa, mandible, and skin but is the secondary flap option for two-layer defects when the fibula is not available. This flap can be applied to soft tissue, partial glossectomy, and pharyngeal defects, but is usually not the first-line option in these areas. The other indication that may offer advantages over other flaps is in palatomaxillary and orbital reconstruction when multiple bone segments and skin paddles are ideal.^{215,220–222} The fascioadipose flap from the scapula system has been applied with excellent cosmetic results to total parotidectomy defects.²⁰⁸

Advantages and Disadvantages

The major advantage of this flap is the ability to transfer large amounts of a large variety of tissue that can be three-dimensionally positioned to fit almost any defect in the head and neck. The potential for multiple bone segments at a distance and right angle to the soft tissue and vascular pedicle allow for many variations in placement and inseting. The major disadvantages include the difficulty with access and patient positioning, and the short pedicle, which makes it more arduous to reach the skull base region. The flap does not have motor or sensate potential and is not ideal for dental rehabilitation with osseointegrated implants.

Preoperative Considerations

Because the scapula flap is not often the initial flap of choice, other donor sites should be considered based on

the recipient site defect, patient occupation and avocations, and functional outcomes. A history of upper back or axillary surgery, radiation therapy, and thoracotomy should be noted, often leading to an arteriogram for vascular analysis. The exam should focus on the upper extremities, back, and axilla, and performing the procedure on the patient's nondominant side when possible. The harvest may be increasingly difficult in the obese patient, leading the surgeon to other reconstructive options.

Techniques (Fig. 3–5)

During transfer of the patient to the operating room, it is imperative to avoid intravenous lines in the ipsilateral extremity. The patient is placed on the bed and positioned with a beanbag. The patient is then placed into the lateral decubitus position with an axillary roll and the ipsilateral upper extremity is placed onto an arm board. The scapula, triceps, teres major/minor, and latissimus muscles are marked to delineate the omotricipital triangle indicating the location of the vascular pedicle. The transverse and descending branches of the CSA can then be identified with the Doppler probe.

The incisions are marked spanning the vascular pedicle and can be placed horizontal to the spine of the scapular, obliquely or inferiorly depending on the location and planned geometry at the recipient site. The flap is harvested from medial to lateral, elevating the fascia, adipose, and skin toward the lateral border of the bone where the pedicle can be visualized just within the deep fascia. The skin flap is then isolated on the vascular pedicle exposing the deltoid, long head of triceps, teres major and minor, and thoracodorsal branches. These are preserved in addition to the associated neural supply to aid in postoperative rehabilitation. At this point, the flap can be harvested as a soft tissue flap by dividing the thoracodorsal vessels, teres major vessels, and scapula bone branches to free the soft tissue for transfer.

Otherwise, further dissection is performed to complete the osteocutaneous flap harvest. The bone flap should include the lateral border of the scapula, but care is taken to avoid the glenoid fossa. The teres major must be separated from the scapula bone but is reattached to the remaining bone following harvest. The height, length, and width of the recipient site bony defect is measured and the appropriate dimensions are divided with a sagittal saw.

Once the geometry has been confirmed, any osteotomies are performed and the bone is secured based on preoperative CT scans and three-dimensional prototyping models to aid in occlusal preservation. If necessary, intermaxillary fixation or intermediate splints are used for accurate placement.

Several variations in the scapula/parascapular/latissimus system are available but are beyond the scope of this chapter. Consideration should always be given to the

flap that provides the best functional and cosmetic outcome with the least donor morbidity.

Wire pass drill holes are placed into the new lateral border of the scapula to secure the teres major to the scapula bone to prevent shoulder and upper extremity dysfunction. The scapula wound is irrigated and closed in a two-layer closure. It is rarely necessary for skin graft closure of the donor site.

The patient is placed in an arm splint for 5 days, and limited range-of-motion exercises commence as early as possible without compromising the microvascular anastomosis in the neck. An inpatient and outpatient physical therapy regimen is strictly followed for the first 4 weeks.

CONTROVERSY

The scapula flap has been the target of a wide variation in opinions regarding the bone stock available for osseointegrated implants, although studies have confirmed the successful use of implants into the scapula bone.^{137,166,223–225}

LATISSIMUS DORSI FREE FLAP

The latissimus dorsi free flap may often be used as a first- or second-line option for scalp and anterior and lateral skull base defects.^{25,226,227} It provides a broad, thin muscle and skin layer for large defects and can be motorized for total glossectomy defects.²²⁸

LATERAL ARM FREE FLAP

The lateral arm free flap provides an excellent alternative to the radial forearm free flap in cases of vascular anomalies or when slightly thicker tissue is needed such as base of tongue defects.²²⁹ It has been used to reconstruct complex parotidectomy defects with acceptable cosmetic results.²³⁰ It does have a smaller, shorter pedicle and may be a more tedious dissection.

JEJUNUM

The jejunal flap has been used extensively in circumferential pharyngoesophageal defects providing functional reconstruction superior to pedicled flaps. It also provides certain advantages over gastric pull-up and colon interposition for cervical defects of the pharynx and esophagus.^{231–234} Due to a lower stricture and fistula rate, it is recommended by some surgeons over the tubed radial forearm; prospective studies comparing the voice and swallowing outcomes have not been performed.²³⁵ It does require a two- or three-team approach, and the abdominal surgery does provide a delay in postoperative recovery.

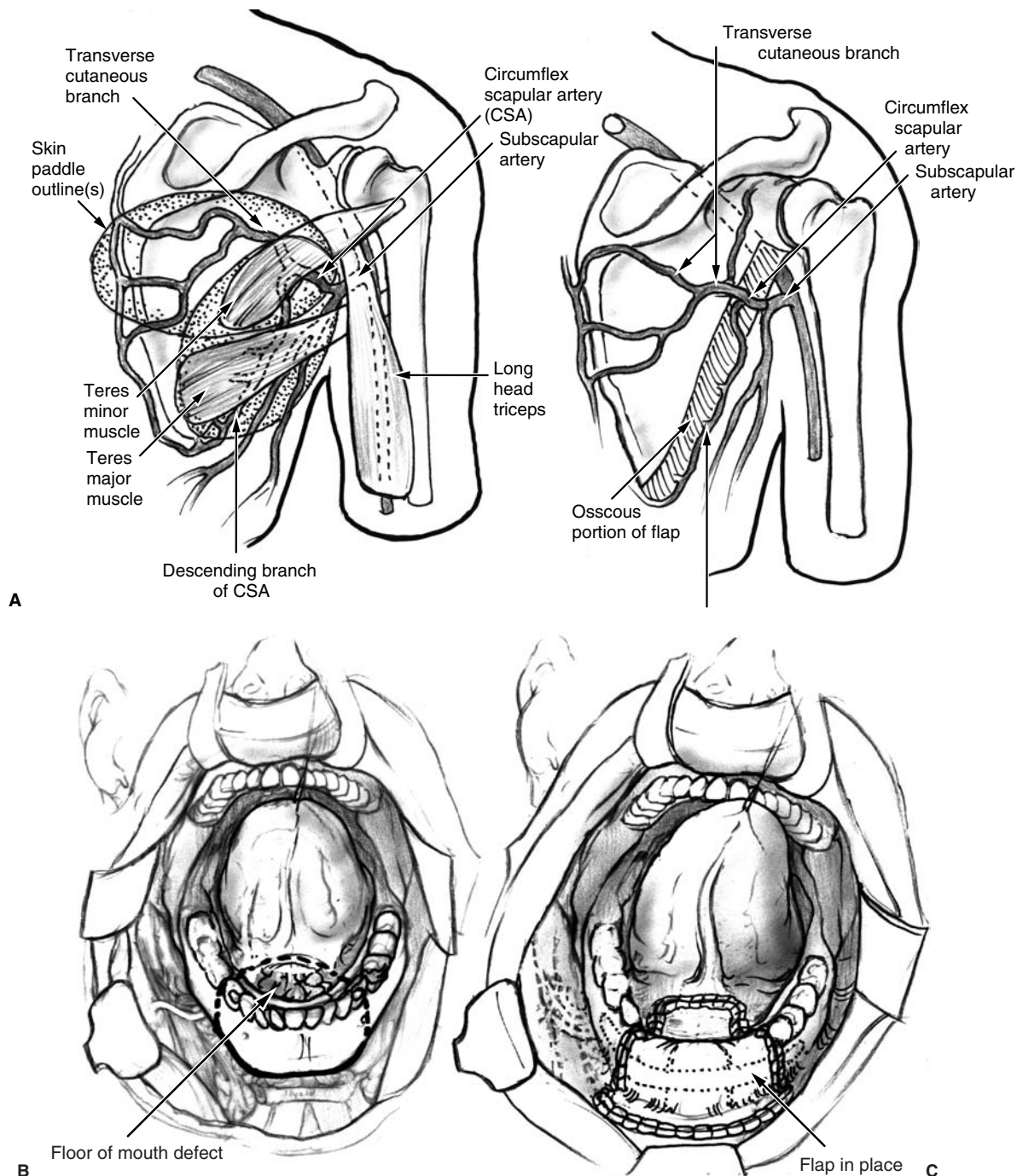


FIGURE 3-5 Scapula osteocutaneous free flap. (A) Anatomic illustration of the vascular structures in relation to a common donor site for a scapula free flap. (B) Recipient site defect for which a scapula free flap is often the best option. (C) Insetting of a scapula osteocutaneous free flap with a parascapular secondary paddle for through-and-through defect.

LATERAL THIGH

The lateral thigh flap has seen increasing use and application for many defects of the head and neck region.^{119,120} It can provide a large area of soft tissue providing functional restoration of tongue, pharynx, scalp, skull base, and soft tissue defects.²³⁶⁻²³⁹

ILIAC CREST FREE FLAP

The iliac crest free flap has lost favor over the past decade due to difficulty with the harvest, lack of a thin and mobile skin paddle, and donor site morbidity. It does provide excellent bone stock for osseointegrated implants and represents a reasonable alternative to the fibula and

scapula free flap for oromandibular and orbitomaxillary defects.^{240–242}

REANIMATION OF THE PARALYZED FACE

Facial nerve paralysis has been described as one of the most psychologically troubling problems of any medical problem.²⁴³ Permanent, complete facial paralysis results in a permanent change in one's facial appearance with obvious changes in smiling, kissing, blinking, emotional expression, public speaking, eating, chewing, nasal breathing, drinking, and even shaving²⁴⁴ (Fig. 3–6). It is common that the otolaryngologist–head and neck surgeon becomes the primary care physician for patients with this problem due to the course of the facial nerve and the complex array of problems in the head and neck region often requiring surgical rehabilitation. It is crucial that the surgeon understand not only the meticulous surgical techniques required for rehabilitation but also the nonsurgical treatment adjuncts and the course of the paralysis usually based on the etiology of the injury. An organized plan for rehabilitation in facial paralysis should take into account the extent and timing of facial nerve injury, viability of proximal and distal nerve fibers, functional state of facial mimetic musculature, and patient-specific factors including medical history and desire for rehabilitation. In general, facial reanimation is divided into dynamic and static procedures. Dynamic procedures are usually confined to neural grafting, locoregional muscle transfer, and free microvascular muscle flaps. This section highlights the important issues that the practicing otolaryngologist–head and

neck surgeon should understand, and provides a detailed account of surgical treatment modalities to incorporate into the care of these individuals.

ANATOMY AND PATHOPHYSIOLOGY OF NERVE INJURY AND REPAIR

A full anatomic description of the facial nerve is beyond the scope of this book; however, for the purposes of reconstruction of representative portions of the face, the facial nerve motor branches to the mimetic musculature are described. The nerve exits the base of the skull at the stylomastoid foramen, at which point it is referred to as the peripheral aspect of the facial nerve. It then courses into the parotid gland after branching into the branch to the posterior belly of the digastric muscle. Through the parotid gland, the nerve courses and begins its major peripheral branching. Following the branching of the facial nerve at the pes anserinus, the superior trunk divides into the frontal branch with a separate division constituting the zygomatic and buccal branches. The frontal branch supplies the frontalis, corrugator supercilii, procerus, and the upper half of the orbicularis oculi. The zygomatic branch has multiple interconnections with the buccal branch and primarily supplies the orbicularis oculi muscle. The buccal branch innervates the zygomaticus major and minor, levator anguli oris, dilator nasi, nasalis, upper half of the orbicularis oris, buccinator, and risorius. As there exist multiple interconnections of this branch, division of one portion of this nerve rarely results in noticeable weakness. The marginal mandibular branch innervates the orbicularis oris, depressor anguli oris, depressor labii inferioris, and the mentalis. The cervical branch innervates the platysma muscle and has connections to branches of the depressor anguli oris, mentalis, and depressor labii inferioris.^{20,245–248}

NERVE INJURY AND REPAIR

Nerve injury has been described using a multitude of terms, descriptions and classification systems. The House-Brackmann system is the most commonly used system to describe the clinical appearance related to degree of facial nerve injury.²⁴⁹ The description by Sunderland is frequently used to describe various nerve injuries. *Neuropraxia* is a term that corresponds with a first-degree nerve injury. In neuropraxia, the axon and supporting layers maintain the structural integrity and recovery is usually complete. *Axonotmesis* refers to a second-degree nerve injury and involves disruption of the axon, although the endoneurium may be intact or disrupted. Wallerian degeneration does occur; however, complete recovery is possible depending on the endoneurium and the reversibility of changes distally at the neuromuscular junction. *Neurotmesis* involves complete disruption of the nerve fascicles and corresponds with Sunderland's third-, fourth-, and fifth-degree nerve injuries. The correlation of

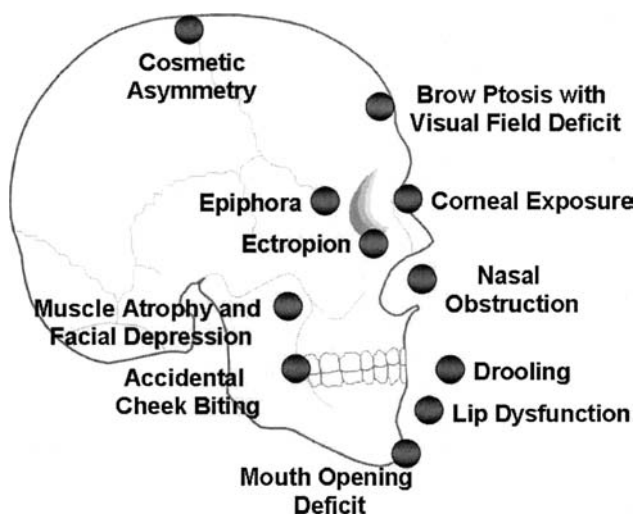


FIGURE 3–6 Common problems related to facial paralysis include cosmetic asymmetry, brow ptosis with visual field deficit, corneal exposure, epiphora, ectropion, nasal obstruction, muscle atrophy and facial depression, mouth opening deficit, lip dysfunction, drooling, and accidental cheek biting.

the classification system with the pathophysiology and clinical relationship is well organized in Table 3–2.

ETIOLOGY

The etiology of a facial paralysis is important to discern prior to institution of therapy, as rehabilitative and therapeutic options differ based on the expected course and recovery of a facial paralysis. The causes of facial paralysis are generally divided into broad categories, which are helpful in organizing the planned intervention.

DIAGNOSIS

The diagnosis of facial paralysis requires knowledge of all possible etiologies and associated problems. It is crucial to identify the etiology and the severity or extent of paralysis as the primary determinants of the eventual approach to rehabilitation. On many occasions, the etiology is readily apparent such as in the case of closed head injury with a temporal bone fracture or resection of the peripheral facial nerve for a parotid malignancy. It is often necessary to perform further diagnostic tests when the etiology is obscure prior to instituting rehabilitation or giving the patient a false sense of hope for recovery when the etiology may result in permanent paralysis.

EVALUATION

It is important to keep in mind that during the entire clinical evaluation of any patient with facial nerve paralysis the examiner should focus on eye protection and consideration and timing of cosmetic and functional rehabilitation, if necessary, of the facial region.

Clinical Evaluation

The history may provide clues into the etiology of the diagnosis. Prior facial nerve palsy is indicative of a more severe problem and usually mandates an MRI scan of the brain and internal auditory canal.^{250,251} Recent infectious problems, surgery, or other medical problems should be fully evaluated prior to excluding these as the cause of the paralysis. The timing and onset of the paralysis are extremely important in determining the extent of injury, and associated symptoms or signs can aid in the topographic mapping of the point of injury. Other medical problems are important not only in the etiology of the paralysis but also in evaluating the patient as a candidate for medical or surgical rehabilitative procedures. If the paralysis was related to a neoplasm, the long-term prognosis and likelihood of recurrence are factors that must be weighed. Likewise, a history of collagen vascular disease, diabetes mellitus, or prior or future radiation to the head and neck region may complicate rehabilitation plans. Finally, it is important to ascertain what component areas of the facial paralysis are noticeable and important to the patient, as the patient's desires may be

different from the surgeon's. The physical exam necessary in evaluating facial paralysis is similar to the routine head and neck examination typically performed by the otolaryngologist–head and neck surgeon or facial plastic surgeon. A full cranial nerve examination is warranted, including examination of each branch of the cranial nerves bilaterally. Certain procedures (i.e., hypoglossal-facial anastomosis) may be contraindicated in persons with multiple cranial nerve injury. The skin type and associated scars are important for future surgical planning. The full examination should document the facial asymmetry by nerve branch at rest, smiling, and looking up. The facial nerve and muscular examination should include the following:

Forehead: The location and presence of forehead creases and hairline should be assessed for surgical planning and cosmetic outcomes. The degree of brow ptosis should be measured and incorporated into the eye examination to prevent visual field loss.

Eye: Eye closure during blink and voluntary closure should be assessed. The Bell's phenomenon, tear production and consistency, corneal sensation, visual fields, and acuity should be documented. The loss of Bell's phenomenon, corneal anesthesia, and dry eye are together considered the "BAD" syndrome, as coined by Guibor, and portends a serious situation suggesting the need for immediate rehabilitation for eye closure and protection. Performing the snap test along with documentation of lower lid eversion can assess lower lid laxity. Eversion of the punctum away from the cornea may result in the loss of tear drainage and epiphora. The amount of scleral show resulting from lower lid ectropion or eversion is helpful in determining the extent of repair of the lower eyelid.

Nose/cheek: Facial paralysis often results in nasal obstruction secondary to loss of dilator nasi function and may be particularly severe with a preexisting valve collapse or septal deformity. The melolabial fold should be assessed, and if present, may signify some slight remaining tone in the muscle. The depth and location are important in surgical planning.

Mouth: The examination of the mouth encompasses a detailed analysis of both upper and lower lip function during rest, smiling, showing the teeth, and puckering the lips. The effect of this dysfunction on denture insertion and retention, drooling, biting, and articulation should be assessed. Laxity and position of the lower lip are important in determining rehabilitation of this specific area. Often the examiner may identify bite marks on the buccal mucosa, and the patient may complain of the inability to take large bites on the side of the paralysis.

Psychological Considerations

It is imperative that the physician allow for patient discussion and interaction to provide a realistic and

accurate assessment of the patient's and the physician's expectations for rehabilitation. It may be beneficial for the patient to view still photos and videotapes showing the facial dysfunction during a variety of facial expressions. Studies have revealed a significant relationship between the facial deformity associated with facial paralysis and depression.^{252,253}

Electrophysiologic Testing

Electrodiagnostic testing is an important adjunct to the physical examination and may provide information related to the severity of facial nerve and facial mimetic muscle dysfunction. This can be used to determine the timing and type of procedure necessary for optimal rehabilitation. It is helpful to document the results of electrodiagnostic testing to provide objective evidence of the neural or muscular function. The currently accepted electrodiagnostic tests include the following^{254–258}:

Maximal Stimulation Test

The maximal stimulation test (MST) is performed following nerve injury and may be helpful for weeks thereafter. It is useful in determining facial nerve degeneration and, therefore, eventual recovery. Using a facial nerve stimulator, stimulation of the nerve on the affected side is compared with that on the normal side. Subjective interpretation of the facial muscle movement at maximum stimulation (often determined by maximal amount of stimulation without discomfort) then reveals no movement, some movement, or normal movement on the affected side. No movement on the MST within 10 to 21 days following injury has been predictive of incomplete return of function, whereas markedly decreased but some movement was predictive of return of function in one study.²⁵⁹ The test has also been used to determine the need for nerve exploration following injury if the MST shows serially progressive deterioration within 21 days of injury. This test is useful only in House-Brackmann grade 6 paralysis.

Electromyography

Electromyography (EMG) is an important test in planning the type of rehabilitation for facial paralysis. Obviously, without functioning muscles for the nerve to innervate, facial movement cannot occur. EMG evaluates depolarization potentials of muscle fibers and groups that constitute motor units. EMG is performed by using a stimulation electrode, which is inserted into the muscle to be evaluated. The muscle is initially tested at rest and should reveal no spontaneous activity. Spontaneous fibrillation potentials are indicative of muscle denervation but cannot usually be identified for 3 weeks following complete denervation. Regeneration potentials are identified as polyphasic action potentials and signify that regeneration is occurring through the spontaneous

discharge of a group of nerve fibers in a motor unit. When muscle function remains after longstanding nerve injury, delay of any surgical intervention may allow for natural functional recovery.

Nerve Excitability Test

The nerve excitability test (NET) is an objective test that otherwise is performed in a manner similar to the MST. It is also known as the minimum stimulation test as it measures the minimum current (amps) necessary to obtain noticeable facial muscular movement on the affected side compared with the normal side. When there was a difference of 3.5 mA or greater from the affected to the normal side, the chance of recovery was found to be significantly decreased.^{260,261}

Electroneurography (ENoG)

Evoked electroneurography is a test using electrical stimulation that can then be recorded through an electrode placed at the muscle stimulated through the nerve being tested. It provides a quantitative measurement of the nerve and muscle function. The procedure is performed by placing surface electrodes proximally overlying the facial nerve exiting the stylomastoid foramen and another overlying the muscle to be tested. An action potential is then recorded if the nerve–muscle complex is intact, whereas in complete degeneration of the nerve or muscle there is no action potential. The values on the affected side are then compared with the normal side to determine the prognostic recovery and whether immediate intervention is indicated. When there is 90% or greater degeneration within 21 days of injury on the affected side, nerve decompression may be indicated following traumatic injury to the nerve.^{256,257,260}

Radiographic Evaluation

The use of 1.0- to 1.5-mm fine-cut CT scans has been the mainstay of radiographic evaluation of the temporal bone for evaluation of mastoid disease, trauma, and preoperative planning, whereas gadolinium-enhanced MRI has been shown to be beneficial in assessing neural abnormalities.^{251,262–267}

REHABILITATION PLANNING

Expected Course of Disease

The common permanent causes of facial paralysis include Bell's palsy, complete division or resection of the facial nerve without repair, and congenital agenesis of the facial nerve. Studies have revealed that recovery with return of facial function is dependent on the etiology and severity of nerve injury.^{268–271} Other etiologies including partial to complete paralysis following trauma and weakness following ear or parotid surgery, which may result in significant recovery over the first postoperative

year that may preclude any surgical rehabilitation. Thus, it is important to understand the natural history and pathophysiology of this problem to allow for optimal functional and aesthetic outcomes.

Immediate Problems

The urgent or immediate issues that must be evaluated and treated include eye protection and avoidance of further injury. If the etiology is thought to be infectious in nature, an immediate course of antibiotics, antifungals, or antiviral agents may be indicated. If there is progressive worsening of partial paralysis, surgical intervention may be indicated to decompress the nerve. If there is not adequate eye closure, saline drops or equivalent should be used in the affected eye every 4 hours while awake. During sleep, eye protection is mandatory and may include an eye moisture chamber protectant, eye patch, or lubricating ophthalmic ointment.

Timing of Surgery

Surgical Decision Making in Facial Paralysis

Rehabilitation of facial paralysis requires consideration of a multitude of problems and a wide variety of therapeutic options. The surgical approach should take into account the following issues and the surgeon's and the patient's priorities.

Choose the procedure that provides the following:

1. Low morbidity.
2. Eye protection.
3. Voluntary and selective movement of individual branches of facial nerve.
4. Natural emotional facial expressions.
5. Single-stage procedure.
6. Absence of synkinesis.

Surgical timing is dependent on the patient's expectations and desires, the facial nerve and related muscle function, and the problems related to the facial paralysis. Facial reanimation procedures are explained to the patient so that he or she understands the difference between static and dynamic procedures. In general, when physiologic repair of the native facial nerve can be performed, it is the technique of choice for rehabilitation. Nerve grafting between a short segment of native facial nerve is the second best option related to natural functional outcome. Finally, cross-facial nerve grafting, hypoglossal-facial crossover, temporalis muscle sling, and free vascularized muscle grafting are options for dynamic rehabilitation if the aforementioned procedures cannot be performed or significant delay has occurred, obviating them as an option. Static procedures are used as an adjunct to dynamic procedures except in rare instances when dynamic procedures are not indicated or available.

The following outline should help the surgeon to organize the potential options in rehabilitation of facial nerve paralysis:

Nonsurgical rehabilitation.

Surgical rehabilitation.

Dynamic procedures.

Static procedures.

Eye Protection

Eye protection is likely the most severe problem that may occur secondary to facial nerve paralysis. Exposure keratitis and corneal abrasion with ulceration can lead to infectious complications and blindness. Eye care is paramount beginning immediately after the facial paralysis is recognized. Early postoperative edema may obscure the diagnosis of inadequate eye closure, preventing the physician from diagnosing and treating the eye prophylactically. Within several days after resolution of the periorbital edema, eye closure and protection may be inadequate, resulting in exposure and risk of complications. The surgeon should prepare the patient for this possibility with prophylactic lubricants and eye protection. An eye cover such as a moisture chamber or eye patch is helpful at night along with a lubricating ointment to protect the cornea during sleep. If the patient works or lives in dry, dusty conditions, an eye patch or moisture chamber may be necessary continuously. Any patient with loss of corneal sensation, such as in fifth cranial nerve paralysis, has greater potential for complications as he or she cannot identify early discomfort in corneal diseases.²⁷² For those patients with limited expected functional recovery, gold weight implant and canthoplasty may be indicated early in the course of the paralysis. Ophthalmologic consultation should be considered in patients with complications related to exposure and in those patients needing surgical eyelid rehabilitation.

Physical Therapy

Physical therapy and physiotherapy have been shown to improve the functional outcome of facial paralysis by involving the patient in the recovery process. Using a mirror, daily stimulation of the facial nerve by manual palpation and voluntary motion attempts may expedite the recovery, although it is crucial to educate the patient on "individual" movements of muscles associated with each nerve branch rather than full facial movement, which may result in synkinesis.

Biofeedback

Studies have revealed some success with functional and cosmetic recovery using biofeedback techniques providing an alternative to standard therapy and surgical intervention when indicated. One method includes the use of

the surface EMG, which allows facial neuromuscular reeducation. This technique has been shown to provide improved facial nerve muscle activity and prevent synkinesis, which may result from nonspecific facial muscle stimulation.^{273,274}

Medical Treatment

Botulinum toxin A has been successfully applied in patients with facial paralysis. Potential uses of botulinum toxin in facial paralysis include blepharospasm, synkinesis, and hyperlacrimation.^{275–278}

Complementary Medicine

There is recent evidence to suggest that acupuncture and modifications of acupuncture may facilitate recovery in facial nerve paralysis.^{279–282} These reports are encouraging, yet these techniques will require evaluation in future controlled clinical trials prior to widespread acceptance.

Camouflage

Using makeup and camouflage techniques, asymmetry and shadow abnormalities may be improved and be less apparent, allowing the patient potential improvement with low risk. These techniques can also be used to alter the perceived shape of the lips, eyebrows, lashes, and skin creases.²⁸³

Static Surgical Rehabilitation

Upper Lid

Upper lid deformity, which can result from severe lagophthalmus, can be corrected with temporary or permanent tarsorrhaphy, gold weight implant, or eyelid spring implantation. The tarsorrhaphy is usually reserved for those individuals who have limited use for binocular vision or have a high potential for corneal exposure-related complications. This procedure also adds to the asymmetry of facial paralysis, further affecting the patient's perception of the facial deformity. It is a simple procedure that is reversible. The eyelid spring has been described by many authors and remains an alternative in eyelid reanimation but has several disadvantages. The spring must be perfectly contoured and shaped to prevent ptosis, it often requires readjustment after implantation, it may result in visible deformity, and it is more time-consuming than other techniques. The author's preferred technique is the gold weight implant, which can provide a natural appearance with a simple, successful, and reversible procedure.^{284–287} There is recent evidence of improved results using the platinum implant.²⁸⁸ It does have the known risk of extrusion, which by some reports is more common as a late complication than as an early complication.²⁸⁹ The technique (Fig. 3–7), which begins with the examination preoperatively to determine the correct size and

weight of the implant by taping a model implant over the eyelid, is ideal for patients with partial eye closure. Topical anesthesia is applied to the eye, and the upper eyelid crease is then injected with 1% lidocaine with 1:100,000 epinephrine. The incision is centered over the lateral border of the pupil and extends to a length slightly less than the length of the implant. The incision extends through the skin, subcutaneous tissue, and orbicularis oculi muscle. The septum and tarsal plate are identified, and elevation is performed superficial to the tarsal plate, exposing a pocket that will envelop the implant and secure it to prevent migration or extrusion. This pocket is elevated to within 2 to 3 mm from the lash line. The edge of the implant with two holes is placed superiorly and is secured by suture last.

Lower Lid

Facial paralysis often results in paralytic ectropion and lid laxity laterally, medially, or both. When the most severe ectropion occurs laterally, a lid shortening with lateral cantholysis and canthoplasty may be the ideal option, although other procedures may also be beneficial when customized to the patient's needs.^{285,290}

Technique: Lateral Canthotomy/Canthoplasty/Lid Shortening

The lateral canthotomy is performed dividing the inferior lateral canthal tendon. A subciliary incision connects to the lateral canthotomy and extends superiorly to the lateral canthus in the crow's feet crease line. The skin-muscle flap is elevated and advanced laterally until the lower lid apposes the cornea and ectropion is corrected. Excess skin and conjunctiva are removed and the lateral tarsal plate is sutured to the periosteum inside the lateral orbital rim to suspend the lower lid in a natural-appearing position. Dermal closure is performed with absorbable suture, and the skin is closed with fast-absorbing gut sutures. The conjunctiva does not require closure.

This technique is depicted in Fig. 3–8. For medial ectropion or with severe eversion and inferior lateral and outward displacement of the medial punctum of the entire lower eyelid, a lower lid sling or medial canthoplasty may be necessary (Fig. 3–9).

Technique: Lower Lid Sling

An incision is made in a subciliary fashion from the infra-pupillary region to the crow's feet laterally. A skin flap is developed in this region and extended laterally in a subcutaneous plane to the zygomatic process. A Lynch incision is made medially and a tunnel developed subcutaneous and anterior to the lacrimal sac, duct, and punctum to connect the incisions. A sling of Gore-Tex or Alloderm is tunneled and divided at the appropriate length. It is secured medially and laterally with a 1.2- × 4-mm titanium screw. The medial screw should be

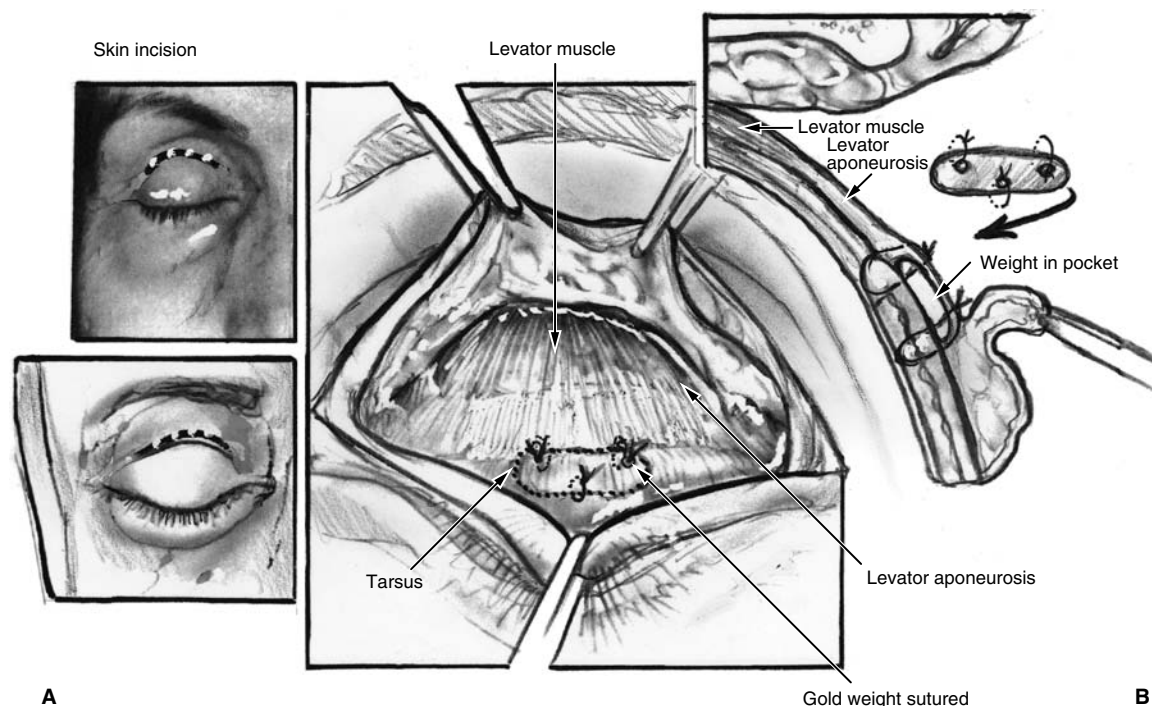


FIGURE 3-7 Gold weight implant technique. (A) Incision placement for planned gold weight implant into the upper eyelid. (B) Anterior and lateral (inset) view of placement of gold weight and sutures in relation to the levator muscle and tarsal plate.

placed just anterosuperior to the lacrimal crest. The lateral screw should not be secured until the lid is in its final corrected position. The wounds are closed using absorbable fine sutures.

Technique: Medial Canthoplasty (Fig. 3-9)

The medial canthoplasty is performed in a similar fashion to the lateral canthoplasty with the exception that extreme care be given the medial punctum and canalicular system. An incision is made in the medial canthus dividing the inferior tendon of the medial canthal ligament. A skin incision is then performed medial to the punctum and extended in a triangularshaped fashion, excising the skin necessary to provide superomedial advancement of the lower lid to attach the inferior tendon in an upward direction to the superior tendon. Resection of conjunctival mucosa also allows for closure of the medial aspects of the upper and lower lids, further reducing the severity of the medial ectropion.

Upper Lip

Static Sling

The static sling is used to provide improved symmetry in the cheek and upper lip during smiling, yet it provides no dynamic or functional facial mimetic muscle rehabilitation. Despite advances in the use of autogenous and alloplastic materials to provide the vector of support, outcomes remain inferior when compared with temporalis transfer or free muscle transfer techniques. Temporalis

muscle, fascia, Gore-Tex and Alloderm have shown successful results when utilized for these procedures.²⁹¹⁻²⁹⁵ Studies have also reported limited need for overcorrection using Gore-Tex and Alloderm as compared with other materials.^{291,295}

Technique

Preoperative assessment at rest, smiling, and during mouth opening should be reviewed with the patient to determine the ideal amount of pull on the oral commissure. The static sling can be approached through a variety of incisions including the preauricular, temporal, crow's feet, melolabial crease, and oral commissure. The preauricular incision is the most cosmetic, unless the patient has previous scars, deep wrinkles, or the need for the re-creation of a melolabial crease. The tunnel is created in a subcutaneous plane from the zygoma to the oral commissure where incisions are performed at the lateral aspect of the upper and lower lip. The orbicularis oris muscle is exposed and a forked distal end of the graft is inserted into the upper and lower lip. Testing of the upward and lateral vector often simulates the outcome and necessitates replacement of the suture in the case of dimpling or buckling of the lip and adjacent skin. Once the ideal cosmetic result and overcorrection is accomplished, the graft is secured to the zygomatic arch near the malar eminence. The graft is then sutured to the zygomatic arch, or a small screw can be used for more rigid fixation to this region.

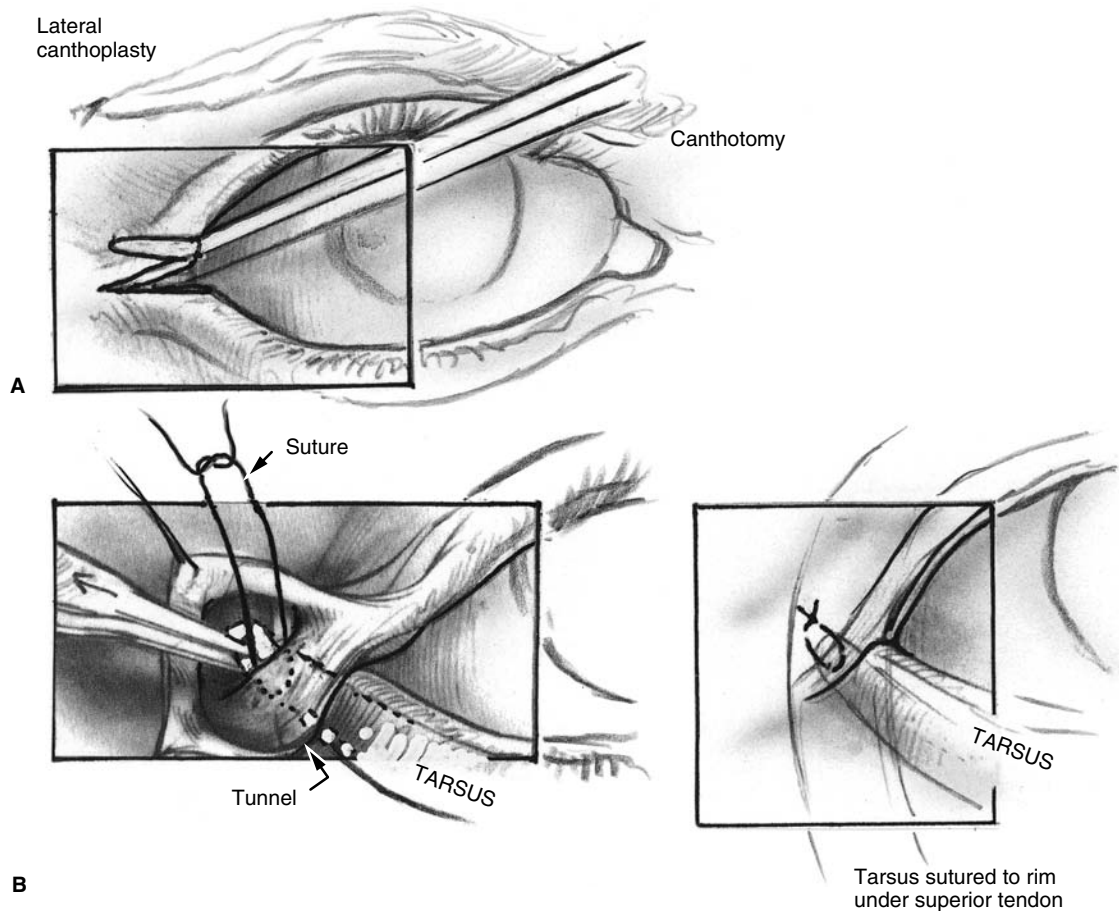


FIGURE 3-8 Lateral canthoplasty technique for paralytic ectropion. (A) Incision placement during a right lateral canthotomy to reposition the lateral canthus superiorly and laterally. (B) Placement of permanent sutures from the lower tarsal plate to the periosteum of the lateral orbital rim.

Lower Lip

Numerous techniques have been described to improve the function of the depressor anguli oris, yet few have been as consistently successful as the lip shortening and vermilion flap.^{296,297} This technique is performed by preoperatively measuring the amount of lip inversion and asymmetry. Once accurate measurements are obtained, a wedge resection can be performed leaving at least 1 cm of lower lip to the commissure. The lower lip inversion is corrected by a resection of a thin width of skin from the ipsilateral lower lip inferior to the vermilion edge to provide symmetry. Vermilion and mucosal advancement is performed to increase the visible amount of lip and provide symmetry to the wet/dry line across the lower lip.

Dynamic Procedures

In the younger patient with congenital or traumatic paralysis, dynamic procedures are proven to provide a more natural, cosmetically acceptable and functional appearance. In a review by Spector of 110 patients with facial paralysis, it was identified that patients who

underwent the primary reanastomosis, cable grafting, and motor neural anastomosis techniques had a much better cosmetic and functional outcome than patients undergoing other techniques.²⁹⁸

Primary Neuroorrhaphy

Primary neuroorrhaphy is the technique of choice whenever possible if it can be performed without excess tension on the nerve endings. This affords the patient the best possible outcome for facial nerve functional recovery. The nerve should be released in an atraumatic fashion both proximally and distally to reduce tension. Mastoidectomy may be performed if a segmental nerve resection peripherally cannot be approximated, thus resulting in reduced tension and easier reapproximation. The technique is the same as described previously for anastomosis.

Intracranial/Temporal Bone

Intracranial repair in the cerebellopontine angle has been described, but the limited exposure and absence of

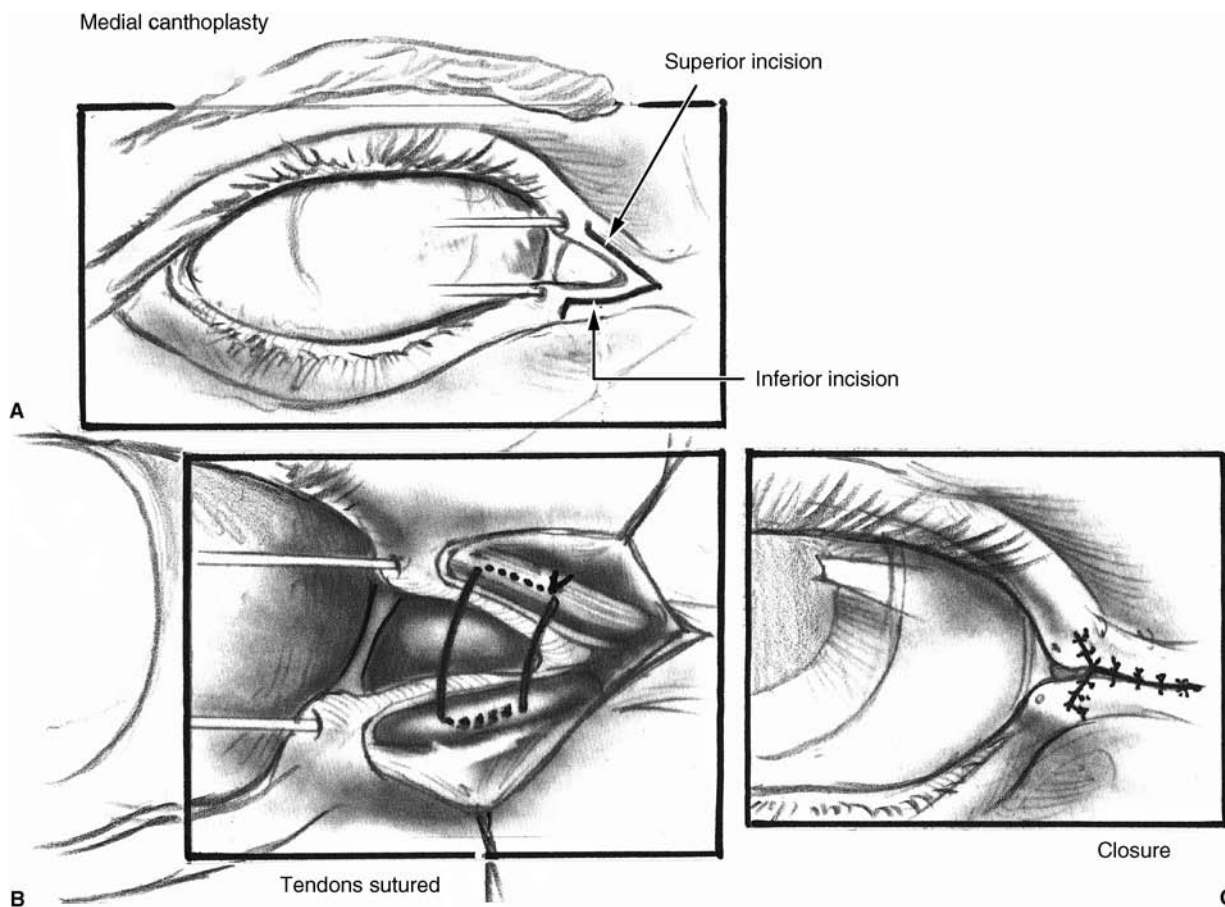


FIGURE 3-9 Medial canthoplasty technique for paralytic ectropion. (A) Incision placement in the right medial canthus. (B) Placement of horizontal mattress sutures to reposition the medial canthus while protecting the lacrimal apparatus. (C) Closure and postoperative view of the medial canthoplasty.

epineurium in this region makes neurorrhaphy and cable grafting more difficult.²⁹⁹ Repair of the facial nerve in temporal bone surgery or in traumatic defects requires special consideration of the timing, type of injury, and expected recovery without further intervention.^{260,299} When primary neurorrhaphy is considered within the temporal bone due to partial-thickness injury, blunt trauma, or heat-related injury, the nerve may alternatively be decompressed and an incision made in the epineurium, leaving the injured but approximated nerve in place for regeneration. If there exists a segmental injury of less than 1 cm, the nerve should be released from the mastoid and reapproximated with suture. If the length of injury does not allow reapproximation, the nerve should be left in place and a cable graft placed in the facial canal after the edges are sharply freshened. This should allow nerve regrowth, and suture is not necessary if the nerve is secure in the canal. The utility of alloplastic hollow nerve reapproximating grafts and tissue glues has not been adequately studied in humans at this time.

CABLE GRAFTING

Cable grafting is often used when there is segmental loss of a section of nerve and nonvascularized reanastomosis of a donor nerve to the two separated ends of the native nerve. The common nerves that are used to cable graft for a segmental defect of the facial nerve include the greater auricular nerve, the cervical plexus, ansa cervicalis, ansa hypoglossi, lateral antebrachial cutaneous nerve of the forearm, and the sural nerve.

NERVE GRAFTING TECHNIQUE

Anastomosis

Despite success with most methods of neurorrhaphy and microvascular anastomosis techniques, controversy remains about fascicular, perineural, and epineural repairs, with evidence to support each technique. It appears that all prescribed techniques seek to minimize trauma, provide perfect coaptation, and prevent axon regeneration outside the epineurium, while also preventing external scar formation within the epineurium.

All nerve grafting should be performed with microscope or loupe magnification and specialized microneural or microvascular instrumentation to avoid trauma to the nerve. Once the ends have been isolated and are tension free, a fresh cut is made near the existing end to allow for the optimal preparation of the nerve ending prior to anastomosis. The suture material should consist of 8-0 to 10-0 nylon and incorporate the epineurium of each nerve ending. The suture should enter the epineurium 2 to 5 mm from the nerve end to reduce tension on the immediate end of the nerve fibers. Nerves greater than 3 mm in diameter may require four to six sutures equidistant around the circumference, whereas nerves 1 mm or less may only accept three to four sutures without posing excess trauma to the anastomosis.

Nerve Graft Harvest

Cervical

Harvest of the nerve graft from either cervical plexus branches or sural nerves appears to result in similar outcomes and should not be the primary determinant of harvest site.³⁰⁰ The advantages of the use of the greater auricular nerve and cervical plexus include the proximity to facial nerve surgery. Additionally, the numerous branches can afford the surgeon the opportunity for a single proximal facial nerve trunk graft to numerous peripheral branches (including a minimum of frontal and marginal branches). As the cervical plexus has both sensory and motor function, reversing the nerve is not necessary. It can be traced toward its origin deep to the scalene muscles if care is taken to avoid trauma to the phrenic nerve and the sympathetic trunk. This nerve harvest is relatively straightforward for surgeons trained in selective neck dissection, which can aid in the isolation of the numerous branches and preservation of the nerve.

Arm

The harvest of the medial and lateral antebrachial cutaneous nerves was popularized through its use as a vascularized nerve graft in association with the radial forearm free flap. These nerves can easily be identified as they run in immediate proximity to the distal segments of the cephalic and basilic veins in the forearm. Incisions may be necessary overlying these veins to provide adequate length for anastomosis without tension.

Sural

The sural nerve represents one of the common nerves used for neural grafting due to its large caliber, ease of harvest, and the location outside of the neck region, which may have been exposed to prior surgery or radiation therapy. There is evidence, however, to suggest that larger caliber nerves have much slower

regeneration capability than smaller diameter nerves. This nerve is located posterior to the lateral malleolus on the posterolateral aspect of the leg and anterior to the Achilles tendon. It can be harvested with full-length incisions or stair-stepped incisions, or by using a vein stripping device.

Cross-Facial

Cross-facial nerve grafting has had varying success; however, its most common uses today include the first stage of a two-stage cross-facial graft followed by a free vascularized muscle graft to the paralyzed side.^{301–304} It had previously been considered when there is not a proximal trunk available for nerve grafting, yet a peripheral nerve and neuromuscular junction with functioning muscle are intact. An extended length nerve graft can then be anastomosed to the peripheral branches of the affected facial nerve (usually limited to frontal and marginal) and tunneled subcutaneously to the contralateral and normal functioning buccal branch for anastomosis. This often requires multiple incisions including a preauricular on the side of the paralysis, melolabial, upper lip/commis-sure, philtral, and contralateral melolabial. The two-stage procedure, burying the cross-facial sural nerve graft followed by a second stage 6 months later, has become more favorable than the one-stage procedure. One large series of 90 cross-facial grafts were then anastomosed at a second stage to a free vascularized muscle graft, with good results.³⁰¹

Hypoglossal-Facial

The hypoglossal-facial crossover techniques have remained popular despite few successes with other cranial nerve anastomotic procedures for facial nerve rehabilitation. It can be performed using the ansa hypoglossi, indirect jump grafting, end-to-side anastomosis, or as a complete transection and reanastomosis of 12–7.^{305–309} The combination of a hypoglossal-facial and cross-facial nerve graft has also been reported.³¹⁰ Results show cross-innervation occurring within several months, with stabilization by 18 months.³⁰⁵ This procedure is reserved for those individuals who do not have a proximal facial nerve stump to innervate a cable graft but do have functional muscle and neuromuscular junctions distally, thus suggesting that the procedure be performed within 2 years of the injury, although there is evidence of success with even more delay.³¹¹ The advantage is the relative ease of the procedure, as it is within the same field as the facial nerve if adequate nerve is available. Otherwise, cable grafts may be necessary to reduce tension and provide adequate length depending on the proximity of the intact native facial nerve. The disadvantage can be significant particularly if the patient has or is at risk for other cranial nerve (CN) deficits in the future such as in von Recklinghausen syndrome. Paralysis of CN 9 or 10 is a

contraindication to the procedure, as is preexisting tongue and pharyngeal functional problems.

Technique

The hypoglossal-facial nerve transfer is performed when there remains functional muscle confirmed by EMG. The preauricular incision is extended into a horizontal skin crease in the neck and the subplatysmal flaps are elevated. The hypoglossal nerve is identified overlying the carotid bifurcation and handled with gentle, meticulous care in an atraumatic fashion. If the hypoglossal nerve is left intact and preservation of ipsilateral tongue function is planned, a 30 to 40% beveled incision is made in the superior aspect of the nerve at the most superficial location. A 5- to 10-mm section of the distal axons in this region is separated to allow space for the cable graft to anastomose to the proximal cut end of the hypoglossal nerve. Two to three perineural sutures are then placed to align the fascicles of the nerve graft to the hypoglossal nerve. Positioning of the nerve graft to the proximal end of the facial nerve should allow for a tensionless suture line even during head turning. The distal nerve graft is then sutured to the facial nerve in the manner previously described. An alternate technique with significant more tongue dysfunction is complete transection of the hypoglossal nerve distally and rotation of the entire nerve into the proximal facial stump. This provides a single anastomosis but significantly increased tongue morbidity.

Dynamic Sling

Dynamic muscle transfer techniques have included the temporalis, masseter, digastric, and even omohyoid muscles, although the technique of partial temporalis transfer remains the most common and successful regional option to date.^{292–294,312} The indications for a temporalis muscle transposition include the following: facial paralysis accompanied by facial mimetic muscular atrophy and facial paralysis in patients who are not candidates for hypoglossal-facial anastomosis or cross-facial nerve grafting. May and Drucker²⁹⁴ report that in 219 patients, over 80% had restoration of the smile, 96% had improved mouth function, and that improvement was evident in the majority by 6 weeks postsurgery. It is worth mentioning that neoneurotization of the facial mimetic musculature has been reported through the trigeminal motor system, and future efforts may involve active use of this system.^{292,313–315}

TEMPORALIS FLAP (FIG. 3–10)

The approach of the temporalis muscle transfer includes a hemicoronal incision exposing the temporalis fascia and zygomatic arch. Incisions are performed in the

vermilion margin of the upper and lower lip at the oral commissure. Additional incisions can be placed at the melolabial crease when this would improve symmetry. The central third of the temporalis muscle and associated fascia is then elevated off of the bone in the infratemporal fossa, taking care to preserve the outer layers of fascia. The 4-cm-wide cuff of muscle is marked with the marking pen toward the coronoid process. The cautery is used to divide the medial and lateral muscle borders from the transposition flap. Two separate 2-0 silk sutures are placed at the distal corners of the flap. A tunnel is then elevated from the zygomatic arch to the oral commissure, paying particular attention to the depth of elevation if facial nerve recovery remains a possibility. In these cases, May and Drucker²⁹⁴ report that elevation is in a subcutaneous plane superficial to the subcutaneous musculoaponeurotic system (SMAS) to preserve potential functioning facial nerve branches, and making the tunnel at least two finger breadths wide has prevented irregular bulging of the cheek. The muscle is then pulled through the tunnel using the silk sutures. Measurements are then taken providing significant overcorrection, and at this point the forked ends of the temporalis fascia are shortened to compensate for this overcorrection. The muscle and fascia are then secured to the orbicularis muscle, providing the cosmesis and overcorrection necessary for facial symmetry.

FREE TISSUE TRANSFER TECHNIQUES

Free tissue transfer for facial paralysis has been particularly useful in congenital bilateral facial paralysis portrayed via videodocumentation of pre- and postoperative smiling. The wide variety of nerve-muscle options include the gracilis, latissimus dorsi, rectus abdominus, pectoralis minor, platysma, and serratus, among others.^{210,301,316–324} These techniques are used when a functional nerve-muscle unit is not present in the facial region. Careful patient selection with consideration of functional recovery of neuromuscular function determines the appropriate reconstructive procedure. Reconstructive options differ for patients with congenital and longstanding facial paralysis versus those with postablative oncologic or surgical procedures.^{210,301,323–327} The inseting of the flap consists of meticulous techniques in placement of the muscle, nerve, and vascular anastomoses. The muscle fibers are sutured to the appropriate location (upper/lower lip, melolabial sulcus, and brow, if necessary) to achieve the optimal result. The proximal nerve may be anastomosed to a cross-facial nerve graft, the motor branch of the fifth cranial nerve at the entry into the masseter or pterygoid muscles or to a hypoglossal, spinal accessory or other functioning motor nerves. In a series of 89 patients undergoing free vascularized muscle grafts, the majority of which were

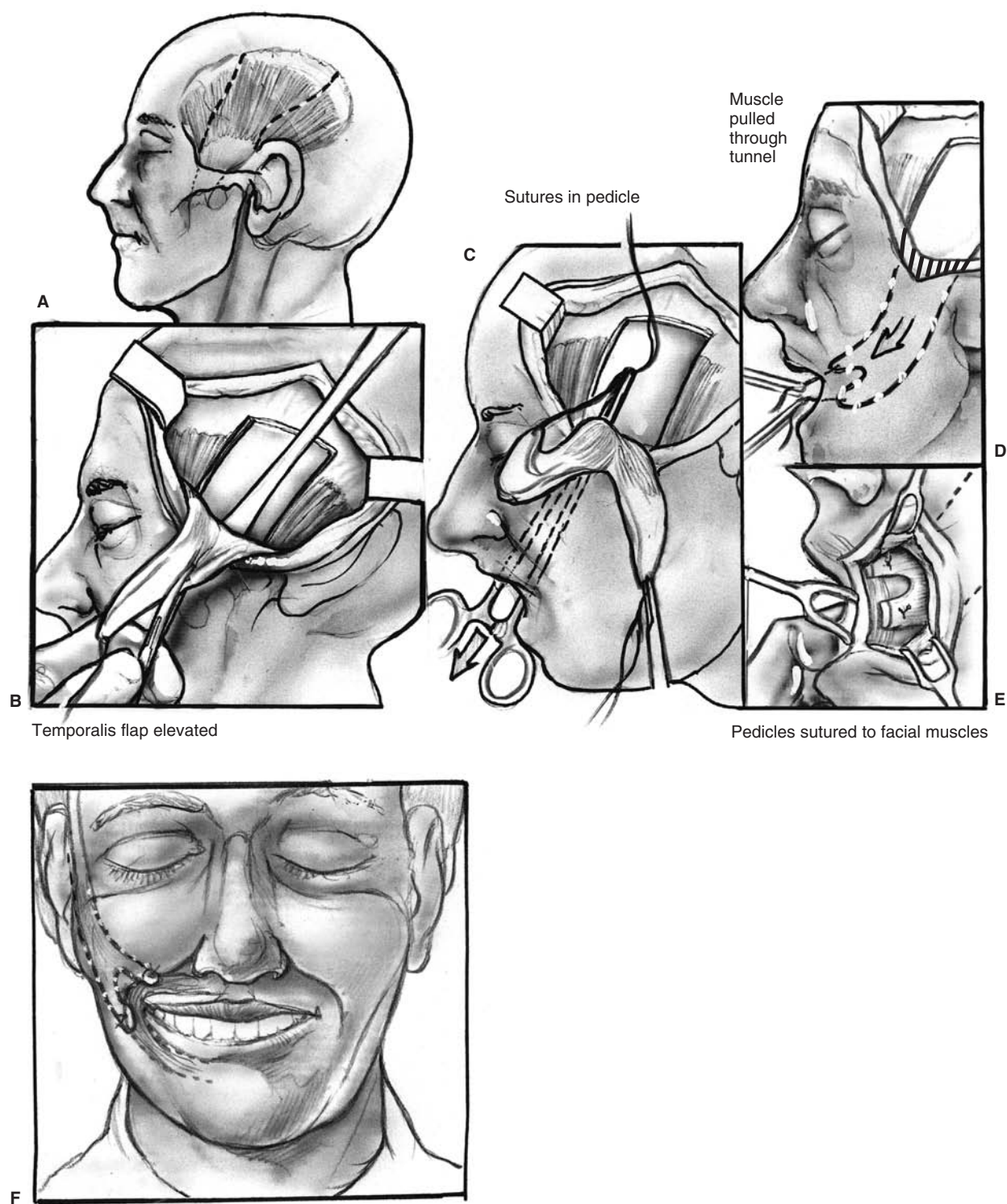


FIGURE 3-10 Temporalis myofascial flap for facial reanimation. (A) Normal anatomic view of the temporalis muscle with divisions of the muscle into thirds. (B) Donor site defect and elevation of the central third of the temporalis muscle using a periosteal elevator. (C) Suture placement into the forked distal ends of the temporalis muscle and fascia. (D) Ghosting of the tunneled muscle through the cheek to the oral commissure. (E) Illustration depicting the location of the attachment of the distal temporalis muscle and the fascia to the orbicularis oris. (F) Postoperative view depicting overcorrection of oral commissure.

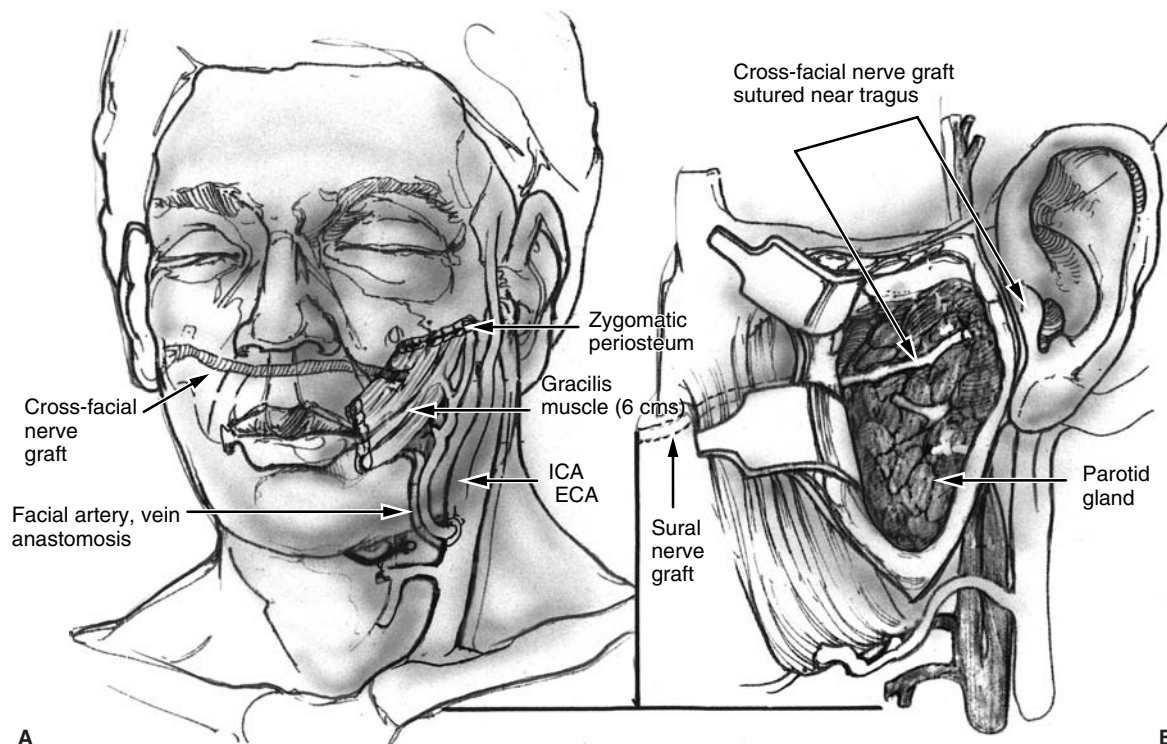


FIGURE 3-11 Cross-facial nerve grafting with neuromyovascular gracilis free flap for facial reanimation. (A) Common placement of the cross-facial nerve grafts from the donor (functional) side to the recipient (nonfunctional side). (B) Insetting of the gracilis muscle and neurovascular anastomoses for facial paralysis.

anastomosed to a cross-facial nerve graft, the average time to onset of muscle contraction was 21.6 weeks postoperatively.³⁰¹ Microvascular anastomosis is relatively straightforward with available facial artery and vein or superficial temporal artery and vein. The applications of free myoneurovascular grafts for facial paralysis continue to evolve, yielding improved cosmetic and functional results, with expectations during the next few decades for a more natural appearance in patients.

TWO-STAGE CROSS-FACIAL/ MYONEUROVASCULAR FREE TISSUE TRANSFER (FIG. 3-11)

The technique described provides for at least a two-stage procedure, which begins with a sural nerve harvest from the lower leg. Incisions are then performed on the nonparalyzed side of the face in a preauricular, melolabial, glabella, oral commissure, or philtral location to expose the buccal and zygomatic branches of the functioning facial nerve. Paralysis is avoided during this procedure, and once the branches of the functioning side are identified, local anesthesia is applied to individual branches, and facial nerve stimulation is performed to identify the dominant branches to this side of the face. The nondominant branches are then divided, and the sural nerve graft is tunneled in a subcutaneous plane to

the contralateral preauricular region. The anastomosis is then performed on the nonparalyzed side to each branch of the sural nerve planned for future reinnervation. The new distal sural nerve graft is then tagged with permanent suture and buried in the subcutaneous plane on the paralyzed side. Six months later, the nerve is identified and the neuroma resected to healthy normal nerve. The free vascularized nerve graft is then harvested from the gracilis or similar donor site with attached motor nerve. The microvascular anastomosis is performed first to decrease ischemia time. Once it is complete, the neural anastomosis is performed to the sural nerve graft and the muscle is then positioned to provide for the most natural appearance to the smile and lips. It is not uncommon for revision procedures or debulking of the flap to be necessary in the future.

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MAXILLOFACIAL AND SOFT TISSUE TRAUMA

John L. Frodel

MANAGEMENT OF FACIAL TRAUMA: GENERAL PRINCIPLES

To properly treat patients with maxillofacial traumatic injuries, a systematic approach should be taken toward both evaluation and treatment. This chapter reviews the basics of evaluation of the patient with maxillofacial trauma, including a reminder of the necessity for the maxillofacial traumatologist to properly understand key resuscitation requirements. Although it is beyond the scope of this chapter to completely review maxillofacial anatomy, pertinent aspects of facial soft tissue and skeletal anatomy are reviewed.

PRIMARY EVALUATION OF THE MAXILLOFACIAL TRAUMA PATIENT

In general, it is appropriate to assume that the total care of the patient with trauma is to be managed by the trauma team in an emergency department setting. However, occasionally those managing the severely injured patient with maxillofacial injuries may not have the background and training necessary to fully evaluate the patient. Accordingly, the maxillofacial traumatologist must be prepared to evaluate all systems in such a severely traumatized patient. Obtaining a thorough history of the traumatic event is essential, as it will assist in directing the evaluation appropriately. For example, a patient involved in a motor vehicular accident is likely to have multisystem traumatic injuries, whereas the patient who is a victim of simple assault or a direct blow during an athletic activity may require only an examination of the injured area. The examiner should be capable of providing a basic evaluation of the chest, abdomen, and extremities.

When the maxillofacial traumatologist is called to evaluate a patient with maxillofacial trauma, the consulting physician should provide information regarding the stability of the patient. In the unstable patient, the “ABCs” (airway, breathing, and circulation) are strictly adhered to. Airway management is of critical importance,

particularly in these patients. Although in some centers patients with significant maxillofacial trauma are routinely intubated, it is not always necessary. A cooperative patient who is breathing comfortably despite evidence of maxillofacial injury may not require urgent intubation unless later evaluation gives rise to suspicion of injuries that may lead to pending airway crisis. Conversely, in a patient who has evidence of significant maxillofacial trauma, as evidenced by significant facial swelling and obvious facial fractures, particularly in combination with evidence of chest injuries or neurologic injury, elective airway stabilization by oral tracheal intubation should be performed. In such patients there is an argument for early intubation prior to the onset of edema either surrounding or in the airway, which might make urgent intubation more difficult. Although isolated maxillofacial injuries requiring early intubation are rare, the following are examples in which an airway should be established:

Bilateral parasymphseal fractures that, because of the attachment of the tongue musculature to the lingual cortex, may allow the tongue base to drift posteriorly and occlude the hypopharynx (Fig. 4–1)

A severe low maxillary fracture (Le Fort I level, particularly with a palatal split) avulsion injury with inferior and posterior displacement of this maxillary fragment

A foreign body in the airway, such as a shattered denture

A blast injury to the mandible or maxillary region with severe displacement and instability of the mandible and tongue region

In these injuries, elective urgent intubation is indicated. In a patient with obvious airway obstruction caused by intraoral pathology (e.g., collapse of the tongue base or maxilla), emergency measures such as placing a clamp on the tongue and pulling it forward can be lifesaving. Similarly, careful placement of a nasal trumpet to bypass a collapsed palate and tongue may also be extremely beneficial. However, in a patient with suspected anterior skull base injuries, care should be taken when placing nasal tubes

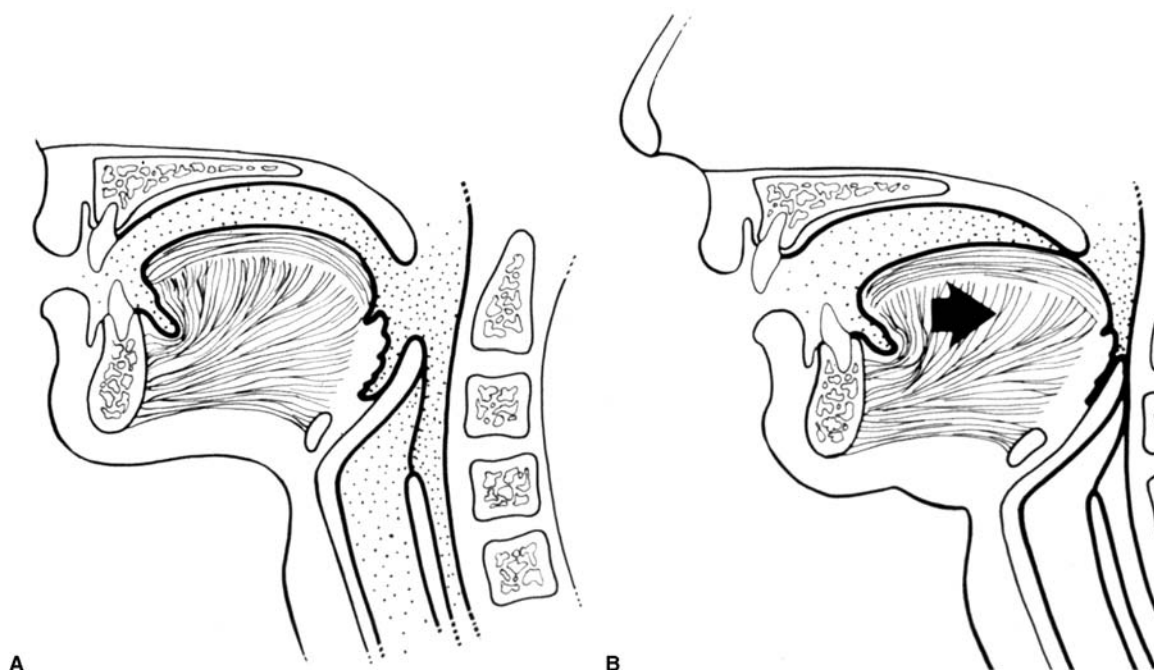


FIGURE 4-1 The tongue base can fall posteriorly with bilateral mandibular fractures, occluding the hypopharynx. (From Sinn D, Hill S, Watson S. Mandibular fractures. In: Foster CA, Sherman JE, eds. *Surgery of Facial Bone Fractures*. New York: Churchill Livingstone, 1987:171–193, with permission.)

to ensure that they proceed in a normal pathway of the airway instead of the superior direction (Fig. 4-2). Fiberoptic visualization can be very helpful in such circumstances.

Oral intubation in the standard fashion is indicated and can safely be performed in the vast majority of patients. Primary nasotracheal intubation is rarely indicated, and when required for fracture management it can generally be performed in the operating room in a controlled environment. However, if for some reason this form of intubation is preferred, nasal endoscopic assistance is encouraged to confirm passage of the endotracheal tube beyond the nasopharynx into the oral and hypopharyngeal region. Endoscopic guidance is also preferred when there is suspicion of either a laryngeal injury or a cervical

spine injury as any excessive or abrupt movements of the cervical spine could cause further damage.

Situations in which an acute airway emergency exists and an endotracheal tube cannot be passed are quite rare now that endoscopic-assisted intubation is widely used. However, in such an acute airway crisis where nasotracheal or oral tracheal intubation is not possible, options are few and transtracheal entry into the airway is necessary. In some centers transtracheal jet ventilation can temporarily ventilate patients long enough to take them to the operating room for an emergency tracheotomy. However, in most situations cricothyrotomy is the procedure of choice. This procedure, in which an incision is made between the thyroid cartilage and cricothyroid cartilage, should be avoided unless it is absolute essential as cricothyrotomy can be associated with laryngeal and subglottic injuries. When this procedure is performed it should be converted within 48 hours to a formal tracheotomy, whenever possible. A more common situation is the need for a formal tracheotomy in a trauma patient, such as a patient with a severe blast injury to the interior mandible and tongue region in which it is predicted that multiple procedures under anesthesia will be required. However, even in these cases it is unusual that a tracheotomy is required emergently, as an oral airway can generally be obtained followed by an urgent, yet standard, tracheotomy.

After establishment of an airway, ventilation (breathing) becomes the priority. A variety of factors can cause difficult ventilation. Aspiration of gastric contents is always a problem and is worsened in the patient who has been intoxicated or has a full stomach. Accordingly, a nasogastric tube should be placed as early as possible to empty the



FIGURE 4-2 This patient exhibits signs of a skull base fracture with cerebrospinal fluid rhinorrhea and periorbital ecchymosis.

stomach contents. A decreased respiratory drive can be the consequence of a neurologic injury, and a patient who is agitated and restless should be considered to have a neurologic injury until proven otherwise. Bleeding from the nose or oral cavity can also contribute to airway blockage and should be treated in a judicious fashion. Finally, when the upper airway is controlled either by intubation or tracheotomy yet there is still evidence of ventilation difficulties, the status of the lungs should be promptly evaluated. A definite cause of ventilation difficulties can be a pneumothorax or hemothorax. Diagnosis of pneumothorax can often be made without x-rays (although a chest film should be obtained for confirmation), and placement of a needle into the superior aspect of the plural space can be acutely therapeutic. Otherwise, one can wait until a radiograph is obtained to confirm the presence of the hemothorax or pneumothorax, and a chest tube is placed between the fifth and sixth intercostals in the midaxillary line.

CONTROVERSY

The literature commonly states that patients with “severe facial trauma” should undergo tracheotomy. With modern intubation techniques using fiberoptic assistance, a tracheotomy is rarely necessary.

Uncontrolled bleeding from the head and neck regions leading to circulatory problems is unusual, yet it occasionally occurs. Most commonly the source of bleeding is the nasal region secondary to nasal and maxillary fractures. Standard nasal packing techniques generally take care of this problem. Occasionally, when there is damage to larger vessels from the external carotid system, more aggressive packing using traditional methods or by placement of the urinary catheter with a 30-cc balloon, can be helpful in controlling the bleeding. When there is damage to larger vessels (the carotid arteries or jugular vein), the bleeding can only be controlled with digital pressure, and as definitive treatment is extremely difficult, it is important to consult with a vascular surgeon emergently.

Other causes of vigorous facial bleeding can be lacerations to branches of the external carotid system. Large amounts of blood can be lost through injuries to these vessels, so urgent management to tie off or suture ligature these vessels is necessary in the emergency department. If there is continued hemodynamic instability, sources other than the head or neck should be sought. These include intraabdominal injuries such as a ruptured spleen or liver injuries, as well as pelvic or extremity fractures, which can lead to significant blood loss.

Although open cranial fractures require early intervention, less obvious injuries may contribute to ventilatory or circulatory problems. Accordingly, formal early neurologic evaluation and intervention by a neurologic surgeon should be obtained. Similarly, it should be assumed that all

patients with facial trauma have a cervical spine (C-spine) injury until proven otherwise. Even patients with injuries indicative of minimal trauma, such as a laceration under the chin, may have a C-spine injury and should be placed in a C-collar. C-spine evaluation and clearance of injury take priority as soon as the patient is otherwise stabilized in terms of the airway, ventilation, and hemodynamics.

SECONDARY EXAMINATION

After dealing with more acute stabilization issues, the secondary clinical evaluation and examination ensue with observation and inspection. Facial wounds are observed, measured, and carefully described in the patient’s chart. Photographs should be taken whenever possible. If examination can take place prior to the onset of severe edema of the facial soft tissues, more information can be gained. For example, once edema sets in, fracture displacement or depressions of skeletal regions such as the zygomatic arch and malar eminence may be obscured.

Of critical importance is the determination of facial nerve function. As will be discussed later in the facial nerve trauma section, one has about 72 hours to determine whether facial function exists acutely. A grimace response can generally be elicited, even in a patient who is comatose, by infliction of a painful stimulus such as pressing the knuckles into the sternum. Lacerations in the cheek and medial canthal regions should lead to a high suspicion for not only facial nerve injuries but also parotid duct and lacrimal system injuries. If the patient is alert and cooperative, basic visual acuity and visual field status should be obtained. Another component of the inspection is the presence of bloody fluids from either the nose or ear. A blood-tinged watery fluid from either site may be suggestive of an anterior or lateral skull base fracture. Similarly, periorbital ecchymosis, postauricular bruising (Battle’s sign), or cerebrospinal fluid (CSF) rhinorrhea may be indicative of a skull base fracture (Fig. 4-2). The medial canthal regions are observed for symmetry and displacement, as is the external nose. The neck is observed for ecchymosis in swelling, which may indicate injury to the deep neck structures, including the larynx and trachea.

PITFALL... If the status of the facial nerve is not noted within the first 72 hours and the patient is noted to have facial paralysis beyond that time, the diagnosis, prognosis, and the decision as to whether to intervene become very difficult to determine.

Following thorough inspection of the entire scalp, face, and neck, palpation of the maxillofacial skeleton and neck is undertaken. The scalp is carefully examined for lacerations that may be hidden by hair. The forehead is carefully palpated for tenderness or step-offs. Lacerations over the forehead, nose, nasal eminence, and mandible are notorious for having associated underlying fractures.

Accordingly, these lacerations should be sterilely probed during the evaluation to palpate for open fractures (Fig. 4-3). Following palpation of the forehead and supraorbital regions, the infraorbital and lateral orbital rims as well as the zygomatic arches are carefully palpated for step-offs and tenderness. Tenderness in the lateral face may be elicited in a zygomatic arch fracture by having the patient open his or her mouth. This pain may also be evidence of a subcondylar region fracture. Palpation then moves down the face to the maxillary and mandibular regions. The mouth is opened and examined for malocclusion (Fig. 4-4). This is followed by careful bimanual “rocking” of the maxilla to check for midface fractures (Fig. 4-5). It is important during this exam to note movement of the maxilla at either the infraorbital rim region (indicative of Le Fort II fracture) or along the buccal sulcus region (indicative of the Le Fort I fracture). Pain is also usually present in the same areas if fractures are present. Many midface fractures are impacted and, accordingly, are immobile. However, tenderness can almost always be elicited.



FIGURE 4-3 Probing of a forehead laceration revealing comminuted fracture fragments.



FIGURE 4-4 Inspection of the occlusion. Note the obvious laceration and fracture in the anterior mandible.



FIGURE 4-5 “Rocking” the maxilla to determine a midface fracture. Note the left hand on the nasal root. It is then placed along the orbital rims.

PEARL... Bimanual “rocking” of the maxilla may not always demonstrate movement, even when a midface fracture is present, as the fracture may be impacted and immobile. However, pain should be elicited in the fracture regions with the maneuver.

Examination continues with palpation and inspection of the external ear, looking for collections of blood, indicative of an auricular hematoma (Fig. 4-6). External canal inspection is performed to rule out damage to the anterior, inferior canal wall, indicative of a condylar impaction into the canal. Tympanic membrane inspection

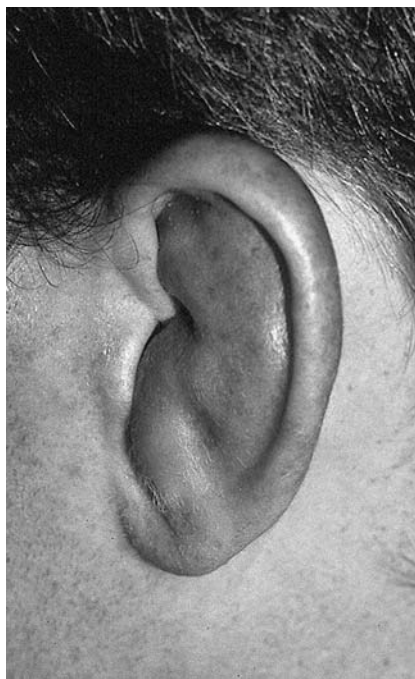


FIGURE 4-6 External ear auricular hematoma. Note the loss of external ear architecture as well as the obliteration of the external auditory canal by this subperichondrial hematoma.

may find tears with or without bleeding, or a hemotympanum. These tympanic membrane injuries, particularly in combination with Battle's sign, may be indicative of a temporal bone fracture of the lateral skull base.

Examination of the various branches of cranial nerve V is undertaken using a cotton swab or pin to determine sensation in each of the divisions of the trigeminal nerve. The nose is palpated for fracture mobility, nasal stability, and tenderness. Any combination of these can be suggestive of not only a nasal fracture but also a nasoethmoid fracture (Fig. 4-7). A nasal exam is performed to observe for either acute septal fracturing or septal hematoma. The latter requires urgent treatment. Finally, the neck is evaluated for tenderness and crepitus. Both of these findings may be suggestive of a laryngeal fracture, particularly when there is airway compromise.

PITFALL... If a septal hematoma is missed on evaluation, eventual external nasal collapse ("saddle-nose deformity") may result, even if an abscess does not form.

RADIOGRAPHIC EVALUATION

Following examination and documentation of facial injuries, appropriate radiographic evaluation takes place. As mentioned previously, if at all possible, injuries to the cervical spine should be ruled out either by traditional cervical spine x-rays or, as is the current practice, by magnetic resonance imaging (MRI). When no other fractures are suspected on physical exam other than mandibular fractures, the radiographic evaluation can be directed toward the mandible itself. A mandibular series should include not only a panoramic radiograph of the mandible but also oblique and anteroposterior (AP) views (Figs. 4-8, 4-9, and 4-10).

For the remainder of the craniomaxillofacial skeleton, computed tomography (CT) scans are the current stan-



FIGURE 4-7 Collapse of the nose on palpation. Note the loss of structural support in this nasoethmoid fracture.

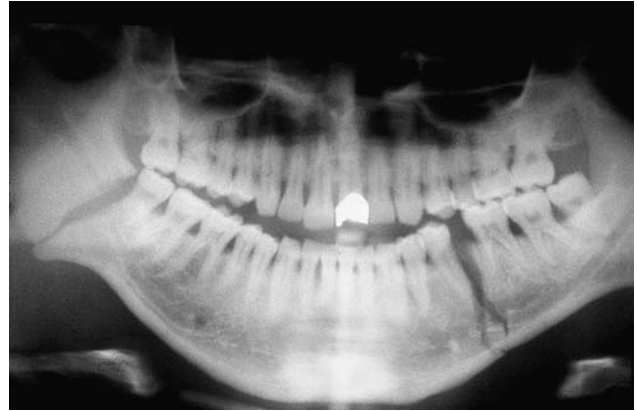


FIGURE 4-8 Panoramic radiograph with a left body fracture (comminuted) and a right angle fracture.



FIGURE 4-9 Anteroposterior (AP) view of a mandibular radiograph, demonstrating a right angle fracture.



FIGURE 4-10 Oblique mandibular radiograph, which best identifies fractures of the opposite mandibular angle.

dard for radiographic evaluation. Axial CT best delineates fractures of the cranium, medial and lateral orbits, and the zygomatic arch, as well as fractures of the mandibular symphysis, body, and angle, and fractures of the

laryngeal skeleton (Figs. 4-11, 4-12, and 4-13). Coronal CT scans are best for identifying orbital floor and wall fractures, fractures through the anterior skull base, Le Fort level midface fractures, as well as subcondylar and

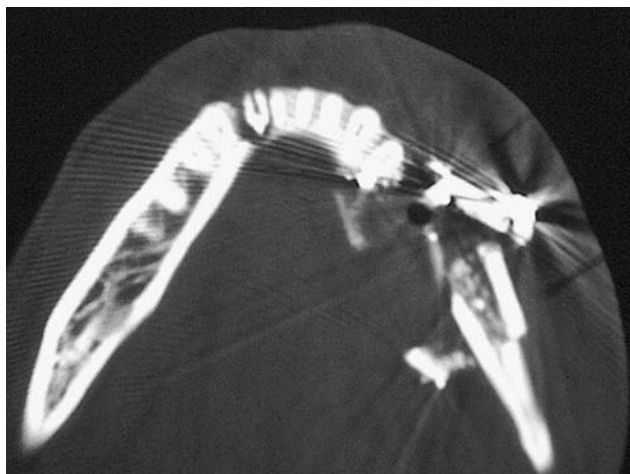


FIGURE 4-11 Computed tomography (CT) of the mandible, demonstrating comminution of the body.

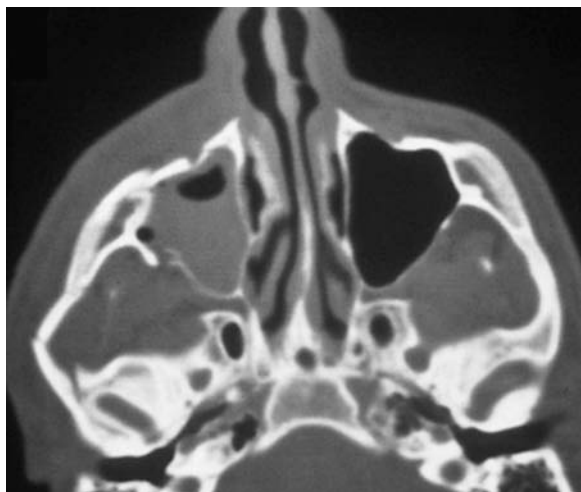


FIGURE 4-12 Coronal CT demonstrating the medial displacement of the right condyle.

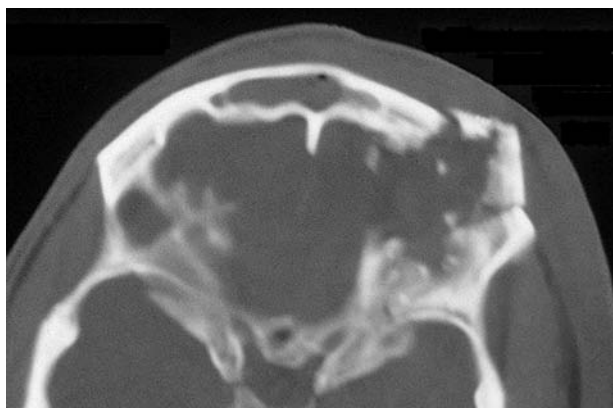


FIGURE 4-13 Axial CT of the frontal cranium demonstrating a fracture of the right frontal bone.



FIGURE 4-14 Axial CT demonstrating multiple fractures of the left zygomatic arch.



FIGURE 4-15 Coronal CT demonstrating a left orbitozygomatic fracture.

ramus mandibular fractures (Figs. 4-14 and 4-15). Three-dimensional (3D) CT scans are occasionally useful but are generally not necessary for the management of acute maxillofacial trauma, although they are essential in evaluating the precise vertical location in subcondylar fractures. Finally, both axial and coronal CT can be helpful in the diagnosis of temporal bone fractures.

GENERAL PREOPERATIVE CONSIDERATIONS

The initial history should include the most recent tetanus prophylaxis as well as the history of rabies vaccination. It is often the case that the patient cannot remember the tetanus history, and so the tetanus vaccine (250–500 U) is given. In cases of an animal bite, rabies vaccine should also be given. Prophylactic antibiotics are often given in these patients, particularly when the dental alveolus and sinuses are involved in the fracture process, or if there is evidence of a contaminated wound. In the latter case,

early aggressive cleaning and irrigation of the wound can be extremely useful and can prevent either acute or secondary infection.

MANAGEMENT OF SOFT TISSUE INJURIES

Soft tissue injuries to the facial region create a myriad of problems for the maxillofacial traumatologist. As the face is the most noticed part of the human body, even small injuries may present in such a manner as to elicit an extremely emotional response, not only from the patient but also from the evaluating physician. Accordingly, these injuries need to be treated with special attention to the emotional component. Many soft tissue injuries to the face are indeed severe, yet because of bleeding and their location on the face, they may be less severe than they initially appear. Conversely, even small wounds can create significant deformities, particularly when placed strategically over an important structure such as the lips, nose, eyelids, and external ear, or in the region of the facial nerve. Accordingly, the maxillofacial traumatologist must have a low threshold for becoming actively involved in the treatment of these types of facial wounds. This section discusses the evaluation and treatment of facial soft tissue wounds. We begin with a few basic principles, and then progress to evaluation and treatment of specific injuries to the important facial structures.

GENERAL PRINCIPLES

In evaluating the facial wounds, one is often dismayed by the severity of the injuries. However, it is commonly the case that once the wounds are carefully cleaned, the surgeon often can return the soft tissues to their normal positions, and, using proper surgical techniques, the surgeon can often reconstruct the tissues in such a manner as to optimize the eventual healing and scarring. It is extremely important to use sound surgical principles in the early management of these wounds. Although most wounds present in a relatively early stage (i.e., within hours of the injury), on occasion patients present with wounds that are significantly delayed (24–48 hours after injury). Fortunately, the excellent blood supply in the facial region helps to prevent infection even in delayed wounds. Although this issue remains slightly controversial, the literature now supports wound closure even in such delayed states. The key remains proper evaluation and preparation of the wound.

One must remember that every wound is potentially contaminated. Accordingly, preparation of the wound in terms of decontamination is very important. The methods for such wound preparation have been described in the literature and are beyond the scope of this discussion. However, it is safe to say that copious and vigorous irrigation of all wounds, with or without diluted antiseptic solutions, remains the mainstay for wound preparation. Conversely, use of full-strength antiseptic solutions

should generally be avoided as they may further traumatize the already damaged tissues.

Grossly contaminated wounds can be of several different types. The first can be a small wound with minimal abrasive components yet with infiltration of a significant contaminant. An example of such a wound might be a laceration caused by industrial machinery, in which oils and dirt may be impregnated into the wound. This type of wound requires sharp debridement of the gross contaminate in combination with significant irrigation for the less visible contaminate. At the other end of the spectrum would be a deep abrasion of the skin where contaminants can be spread over a large area (Fig. 4–16). Simple irrigation in this situation is generally inadequate. In these cases pressure irrigation, using an orthopedic pressurized irrigator, is often the best way to irrigate and debride these wounds. Sharp debridement may also be required for deep embedded foreign bodies. In any wound in which there is suspected contamination, it is wise to use a prophylactic broad-spectrum antibiotic (such as a cephalosporin) as early as possible in the evaluation of the wound. This is particularly the case in animal and human bites.

PEARL... A dirty, contaminated, abraded wound can be cleaned very well with pressurized irrigation.

Unfortunately, many facial lacerations are of the avulsion type, in which there is often an oblique or “skived” component to the wound in which the skin edge is not at 90 degrees to the skin surface. The skin edges in these wounds are partial thickness along the avulsed edge and may sometimes be devascularized (Fig. 4–17). There may be a tendency to aggressively debride these edges back to completely normal-appearing tissue. This more aggressive debridement is appropriate in wounds in which there is



FIGURE 4–16 Patient with severe abrasions of the upper face and forehead.

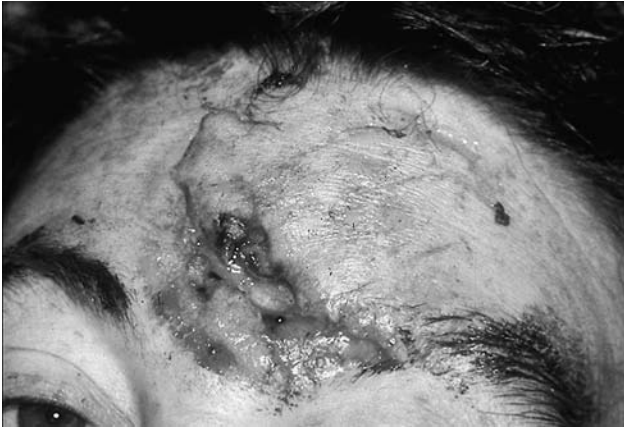


FIGURE 4-17 A significant avulsion wound of the forehead. Note the probable necrotic area in the medial inferior aspect of the flap.

obvious excess of soft tissue adjacent to the wound (e.g., in an elder patient with lax skin in a cheek wound). However, as wound closure is the goal, many wounds cannot afford complete debridement back to totally normal-appearing skin (e.g., a young patient with an avulsion nasal wound). Accordingly, in such cases a scalpel is used to create a right-angled (non-beveled) wound edge to allow for optimal closure with wound eversion.

PITFALL... Excessive wound edge debridement may lead to the inability to close the wound primarily.

WOUND CLOSURE

For more detailed descriptions of wound closure techniques, the reader is directed to the suggested readings at the end of the chapter. However, several comments can be made here. First, some controversy remains regarding the treatment of human and animal bites. The literature now supports closure of animal and human bites after copious irrigation and institution of antibiotic therapy. Although a risk of infection in such wounds exists, the blood supply to the facial region appears to significantly decrease the chance of infection in such wounds relative to those in other parts of the body (e.g., fingers). Accordingly, bite wounds can generally be cleansed aggressively and closed unless they are several days old or obvious infection already exists. It is important, however, to maintain antibiotic coverage for at least 7 to 10 days after wound closure.

CONTROVERSY

Animal or human bite wounds to the face can and generally should be closed as with other wounds. Copious irrigation and antibiotic coverage is particularly important.

Regarding wound closure techniques, closure of all facial wounds caused by traumatic injuries should be in a manner that one would use to close any wound in the face. Using basic principles, subcutaneous wound closure that bears the tension for the wound is followed by use of eversion suture techniques for skin closure. A vertical mattress suture technique appears to optimize this goal of eversion (Fig. 4-18). It should be noted that in lacerations in which there is tissue loss, either by evulsion or by elective debridement, there may be a skin thickness mismatch. It is important in such situations to properly place the subcutaneous sutures so as to level out the thickness of the skin edges such that a step-off deformity is avoided.

PEARL... When faced with closure of layers of different thicknesses, placement of the subcutaneous sutures should be superficial on the thicker side and deep on the superficial side.

The choice of suture material is of secondary importance. However, because of the difficulty of removing permanent sutures in uncooperative patients (such as in children), a resorbable suture, such as a fast absorbing gut, is often preferred. Similarly, the use of braided sutures in contaminated wounds might be avoided.

ANESTHESIA

Most facial lacerations can be evaluated and repaired in the emergency room setting. However, complex lacerations that require absolute patient immobilization and take longer than 2 to 3 hours to repair might be best treated in the formal setting of the operating room. Children with even less complex wounds may best be treated under anesthesia. However, techniques have evolved with anesthetics that allow increasingly complex wounds to be repaired in the emergency room setting. While taking the history and evaluating the patient's wounds, the surgeon may be able



FIGURE 4-18 Cheek laceration closed with adequate eversion techniques, using alternating vertical mattress and simple suture closure.

to determine the emotional stability of the patient. Many patients are of adequate stability to undergo lengthy complex repairs without the addition of sedation. On the other hand, some patients, particularly children, may require light sedation to allow the surgeon to complete the evaluation and repair. There has been increasing use of sedatives such as midazolam given either intravenously in an adult or transmucosally (intranasal or sublingual). This may provide adequate sedation to stabilize the patient during prolonged repairs.

It should be remembered that nerve blocks can be very helpful in patients with large facial wounds. Accordingly, anesthetizing the three branches of the trigeminal nerve (supraorbital, infraorbital, and mental nerves) is advised, when appropriate. Topical anesthetics may be helpful in some patients. Some surgeons advocate the use of a paste made up of topical anesthetics (e.g., tetracaine, epinephrine, and cocaine [TAC]). Although TAC topical anesthesia has been found to be extremely helpful, there are several reports on its cardiac toxicity; accordingly, it is banned from many medical centers.

Finally, injectable local anesthetics remain the mainstay of anesthesia and, even when nerve blocks are utilized, injection of local anesthetic into the wound margin is generally necessary. Standard combinations such as lidocaine (Xylocaine) 1% with 1:100,000 epinephrine and lidocaine 0.5% with 1:200,000 epinephrine are commonly used for this purpose. It is important to note that the purpose of the epinephrine is to provide vasoconstriction and, accordingly, one must wait 5 to 10 minutes to obtain maximum effect. Although it is commonly stated that one should not use epinephrine-containing local anesthetics in regions such as the ear and nose, this can safely be used unless there is an obvious tenuous blood supply to an avulsion segment.

PITFALL... A bad situation can be made worse with an uncooperative patient; have a low threshold for providing a sedative or general anesthesia.

TREATMENT METHODS FOR SPECIFIC WOUND TYPES

Hematoma

Hematomas occur when the tissue plane is sheered free from an adjacent tissue plane, creating a space for the potential accumulation of blood. This occurs with relative frequency, and it generally can be treated conservatively; examples are hematomas of the cheek, forehead, and scalp regions (Fig. 4-19). Although there is a tendency to aspirate such hematomas, it is generally not necessary, as blood will be absorbed without any additional intervention in most situations.

The exception to this conservatism is when a hematoma occurs in either the nasal septum or external



FIGURE 4-19 Patient with a right forehead hematoma.

ear. In these cases, blood accumulates between the perichondrium and the underlying cartilage. Accordingly, pressure necrosis can occur with resultant instability and deformity of the structures. This can lead to a perforated septum and external nasal collapse in the nose and a deforming loss of contour of the external ear. The treatment of these specific hematomas is discussed in the sections on ear and nasal lacerations.

Abrasions

Abrasions are quite common. Most abrasions are superficial and heal quite adequately without significant intervention. However, if dirt or other types of foreign bodies are embedded within the abrasions, it is extremely important to provide superficial debridement to prevent traumatic tattooing. Although the use of a surgical scrub brush is commonly described as a way of removing such embedded debris, one must be extremely careful using such abrasion



FIGURE 4-20 Patient with severe abrasions of the face and nose.

techniques. The over-aggressive use of a scrub brush may convert a superficial wound into a deeper partial-thickness or a full-thickness wound. As mentioned previously in the discussion on wound preparation, a high-pressure irrigator is most useful in such situations (Figs. 4-20, 4-21, 4-22, and 4-23). Residual debris should be meticulously removed by direct excision, and the residual oils or grease may be removed using solvents such as acetone.

PEARL... Use high-pressure orthopedic irrigation systems to cleanse abraded wounds.

Meticulous posttreatment wound care is of critical importance. It has been clearly demonstrated in the wound-healing literature that a moist wound heals better than one that is allowed to desiccate. Accordingly, frequent cleaning of the wound followed by continuous moist coverage using an ointment or special topical

dressing is recommended. Although it is commonly stated that antibiotic ointment should be used, the efficacy of the antibiotic component in these ointments has not been proven. Accordingly, ointments such as petroleum jelly or vitamin A and D are generally adequate and have less likelihood of a localized adverse tissue response than do the antibiotic-containing ointments. The use of such semioclusive ointments allows for ease of wound cleaning, prevents crusting of the wounds, and allows for more rapid epithelialization of the wound. Similarly, they lessen the apparent pain caused by the wound, thus making the patient more comfortable.

Avulsions

As discussed earlier, avulsion wounds occur quite commonly. They present a variety of problems because of the devascularization that occurs at the wound edges. Many of the adverse healing aspects of such wounds are beyond the control of the surgeon. However, although debridement



FIGURE 4-21 Pressure irrigation for cleansing and mild debridement.



FIGURE 4-22 The same patient as in Fig. 4-21 after pressure irrigation cleaning. Note that the cheek wound has areas of full-thickness loss.



FIGURE 4-23 The same patient as in Fig. 4-21 nine months after second-intention wound healing.

of wound edges is commonly necessary in avulsions flaps, one should still attempt to reposition the avulsion segment using sound wound closure techniques. The obliquely avulsed wound edges should be sharply yet minimally excised followed by use of wound eversion techniques on the skin. Avulsions that are based superiorly tend to heal adversely with a “pin cushion” type of deformity. This deformity of wound inversion in combination with thickening of the distal component of the flap is almost predictable. It is important to counsel the patient as to the likelihood of this deformity and the probable need for secondary scar revision once the wound has healed.

PITFALL... Partially avulsed segments routinely heal with inversion problems such as “pin-cushioning.” Prepare the patient for the likelihood of secondary scar revision.

The treatment of complete soft tissue avulsions presents a unique set of problems, both practically and philosophically. Evaluation of the wound relative to its depth and the involvement of deeper structures, the proximity to critical structures such as the lip and eyelids, and determining the patient’s ability to care for the wound are of utmost importance. Second-intention wound healing plays a major role in such avulsions. However, the avulsed wound must be in a location ideally situated for such second-intention healing. Examples of excellent locations include superficial avulsions of the forehead, temple, and occasionally the cheek, as well as small defects on the tip of the nose. These are the same locations in which second-intention wound healing would be used as the treatment for defects created after the excision of superficial skin cancers. Conversely, avulsed defects near the lips, ala, and eyelids may not be ideal for such delayed wound healing as contraction and subsequent distortion of these important structures may occur. Similarly, avulsions of tissue over the forehead or nasal dorsum may not heal adequately if bone and cartilage is exposed. But wounds *may* heal over such exposed bony structures if excellent wound care techniques are adhered to. The latter is completely dependent on the patients’ ability to comply with wound care instructions, and they must be aware that such second-intention healing over bone and cartilage may take many months to occur.

CONTROVERSY

Traditionally, second-intention healing has not been attempted over exposed bone. However, with meticulous moist wound care, such healing may occur.

Soft tissue grafting may be used in the primary setting after the wound is cleaned. Composite grafts for structures such as the nasal ala may provide primary healing but may not result in an optimal cosmetic appearance. Accordingly, if such grafts are used in regions such as the scalp, cheek, temple, or forehead, the patient should once again be counseled that secondary revisions may be required. In the rare event that a segment of avulsed nose or external ear is brought with the patient, attempts can be made to repair the structures with the original avulsed tissue. The tissue should be meticulously cleaned, carefully debrided, and then sutured into place as a composite graft. Although these repairs are only occasionally successful, it is worth the effort, as the tissue may still be better than any other option, and it prevents the waste of a donor site that may be useful in a secondary repair.

Finally, although local flap reconstructions are generally reserved for the treatment of secondary deformities, the use of such local tissue flaps may be appropriate in the primary setting when options are limited. This is particularly the case when significant deep structures are exposed and when questions exist as to the patient’s ability to care for an open wound.

PITFALL... Use local tissue flaps only when absolutely required, as “bridges may be burned” in using tissue that may be more useful in a secondary setting.

Massive Soft Tissue Losses

It is quite rare that patients lose large sections of soft tissue in routine accidents. However, blast injuries to the face, such as with shotgun wounds or other etiology such as burns, create very difficult treatment dilemmas. It is important to realize that patients with these severe injuries should be treated as multisystem trauma victims, and they often require basic resuscitation in addition to evaluation and treatment of the facial wounds. There are often airway and circulatory issues that take precedence. Intracranial and other neurologic injuries may be present. Blast injuries to the face inevitably have underlying structural abnormalities as well. Although it is beyond the scope of this book to discuss in detail the treatment of complex blast injuries, suffice it to say that to have adequate soft tissue reconstruction, the underlying facial skeleton must be reconstructed. Just as it is of critical importance in reconstruction of the external nose to have adequate underlying structural support, the same can be said of the remainder of the face. If structural support does not exist, collapse and devastating contraction of the facial soft tissues will occur. Accordingly, the current standard of care for blast injuries of the face involves careful debridement of obvious facial wounds, evaluation of soft tissue deficits (which are often less than expected),

followed by reconstruction. Blast injuries were traditionally treated with the principal goal of obtaining soft tissue closure. Such injuries are currently treated acutely with limited debridement followed by further debridement after several days, if necessary. The full blast affect may not be fully shown for several days and, accordingly, repair after the first 2 to 4 days is appropriate. After the wound edges are demarcated, definitive debridement can be performed followed by immediate reconstruction. Although local tissue can often be used to close much of the defect in the primary setting, distant flaps are often required to provide adequate soft tissue closure (Figs. 4-24, 4-25, and 4-26). Once again, the goal

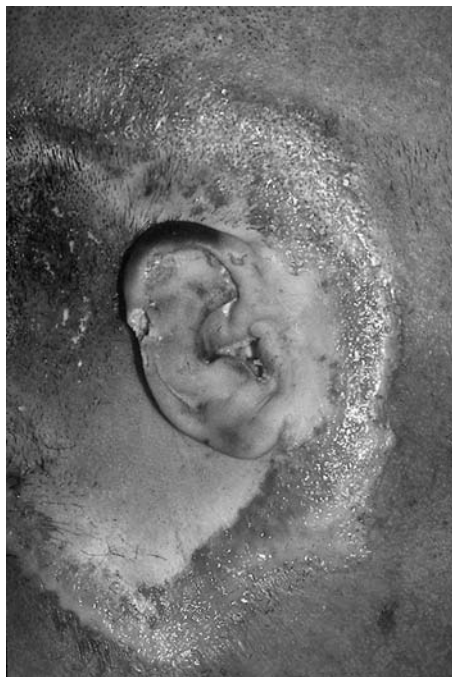


FIGURE 4-24 This patient sustained an electric burn from a 10,000-V live power wire to the right mastoid and neck region.



FIGURE 4-25 After debridement of necrotic soft tissues and lateral temporal bone (with dissection of the facial nerve) and placement of a scapular skin fascia cutaneous free flap.



FIGURE 4-26 Six months postreconstruction. Patient deferred further scalp, neck, and prosthetic auricular reconstruction.

in these patients is to provide coverage of important underlying structures, such as the bony facial skeleton and skull base, as well as to prevent contraction of nearby facial structures. Accordingly, the cosmetic result is less important than function and prevention of secondary contraction.

WOUNDS OF SPECIFIC ANATOMIC STRUCTURES

Eyelid Lacerations

Eyelid wounds commonly occur in maxillofacial trauma. There is perhaps no injury in the face that elicits greater emotion and should also compel the surgeon to obtain a detailed history as to the etiology of the wound. The injury can be from blunt trauma, such as the result of an interpersonal altercation or in a motor vehicle accident, or from a penetrating object. In either case one must suspect deeper injury to the globe or bony orbit. Regardless of the etiology, an ophthalmologic consultation is essential to rule out globe injury or injury to the adnexal structures. Of particular concern are globe puncture injuries, hyphema (hemorrhage into the anterior chamber), and corneal abrasions. As only an ophthalmologist has the equipment to properly evaluate these globe injuries, consultation is a must. Patients with globe injuries require aggressive treatment such as globe repair for puncture, eyelid mobilization for corneal abrasion, and strict bed rest for the high pressure created in the presence of a hyphema. Similarly, lacrimal canalicular injuries are difficult to detect without proper probe instrumentation. The ophthalmologist may be best suited to determine

this injury. Extraocular muscles are occasionally injured in seemingly benign trauma as well.

An often-missed injury in a setting of primary trauma is injury to the levator aponeurosis. This injury to the upper eyelid can occur even without the presence of an open wound. Accordingly, one must have a thorough understanding of the surgical anatomy of the eyelid. In the presence of a superficial wound of the upper eyelid, the wound should be explored to determine the continuity of the levator mechanism. If a laceration is vertical in orientation, a subsequent lid ptosis is less likely. However, wounds that are larger and more horizontal in orientation may likely create trauma to this aponeurosis. Repair involves reattachment of the aponeurosis or muscle fibers with small resorbable sutures.

PEARL... Vertical upper lid lacerations are less likely to result in secondary lid ptosis than are horizontal lacerations.

Regarding the lacrimal drainage system, one should have clear understanding of its anatomy from the superior and inferior canaliculi, which drain into the lacrimal sac and eventually into the lacrimal duct (located in the lacrimal bone), which drains into the inferior meatus. Any laceration in the medial canthal region is likely to cause an

outflow obstruction. It should be noted that injuries to the nasolacrimal duct, which are commonly present with nasoethmoidal fractures, may not require primary repair as reduction of the fractured region may allow persistence of outflow after the edema has subsided. However, canalicular injuries should be treated immediately. Under magnification, the severed canaliculus is observed and then cannulated and dilated with punctal dilators. It is important that this initial repair be performed as early as possible, because with time the tissues become edematous and the canalicular stump is often retracted. If at all possible, a Crawford tube (silicone stent) is passed through the superior and inferior canaliculi and tied inside the nose in the inferior meatus (Fig. 4-27). This repair is often best performed by an oculoplastic surgeon, although a skilled and experienced facial plastic surgeon may also perform the procedure. Endoscopic or percutaneous dacryocystorhinostomy is reserved for secondary settings.

PEARL... Lacerations through the medial eyelid often sever either the superior or inferior canaliculus. Primary repair is optimal.

The upper and lower eyelids can be considered to have two layers, the anterior and posterior lamellae. In both eyelids the anterior lamella consists of the skin and

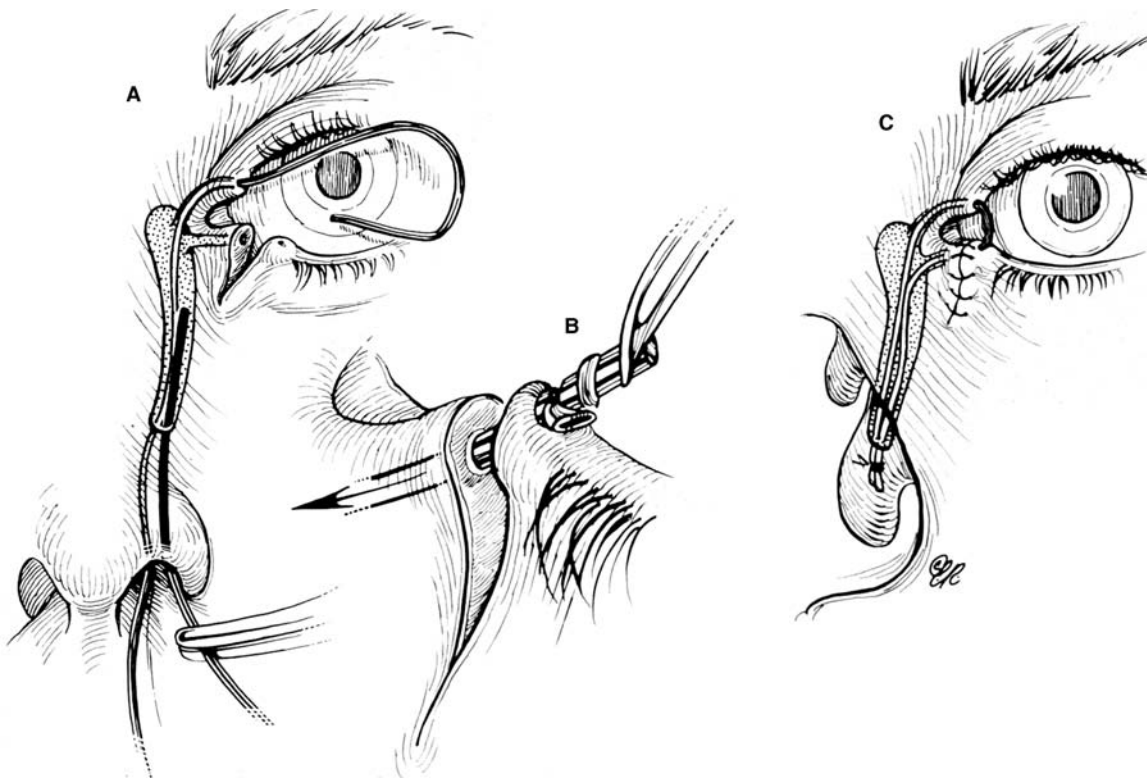


FIGURE 4-27 Diagram depicting repair of a canaliculus laceration with silicone tube intubation of the superior canaliculus (A), the inferior canaliculus (B), and with tying of the tube in the nasal cavity (C). (From Lisman R, Spinelli H. Orbital adnexal injuries. In: Sherman JE, ed. *Surgery with Facial Bone Fractures*. New York: Churchill Livingstone, 1987:114, with permission.)

the underlying orbicularis oculi muscles. The posterior layers consist of a fibrous tarsal plate and the septum in both eyelid margins. The tarsal plate attaches to the orbital septum and underlying specialized soft tissues. On the lower eyelid the latter consists of the orbital septum and orbital fat as well as the capsulopalpebral fascia. In the upper eyelid, the orbital septum is most superficial, with deeper layers being the underlying orbital fat, the levator muscle and aponeurosis, and then the conjunctiva. Accordingly, as mentioned previously, a greater concern exists with upper eyelid injuries because of the significance of the deep musculature.

Lacerations involving the margin and tarsus can be repaired systematically from the posterior lamella to the anterior lamella. The traditional description for closure of the lid margin is placement of sutures aligning the lash line, the meibomian glands, and the gray line in the posterior aspect of the laceration (Fig. 4-28). These are placed using a permanent suture that is cut with long residual "tags" so that it can be tied inferiorly so as not to scratch the cornea during the healing process. A slight eversion of the lid margin is optimal to prevent inversion or notching of the lid following the healing process. The tarsus is repaired with an absorbable suture, and the conjunctiva may be closed with a 6-0 rapidly absorbing suture. Some surgeons prefer

not to close the conjunctiva. Finally, the orbicularis oculi muscle is reapproximated with a small absorbable suture.

If there is avulsion of tissue, this is generally not a problem in elderly patients with lax eyelids, as enough tissue can be mobilized without difficulty. However, when lid laxity is minimal, such as in younger patients, tissue must be mobilized to close the defect. A lateral canthotomy and inferior cantholysis generally allow for adequate mobilization to perform the repair. It has been stated that the latter maneuver may provide up to 4 to 5 mm of tissue release. When more than 5 mm of tissue is necessary, a semicircular flap (Tenzel) can close the defects of up to half of the lower eyelid and similar defects of the upper eyelid.

In an acute setting, avulsed segments of the eyelid can be retrieved and resutured in position as a composite graft. Such free grafts occasionally heal.

SPECIAL CONSIDERATION

With any eyelid wound, particularly if there is tissue loss, remember to protect the cornea during the repair and to prescribe a lubricant postoperatively.

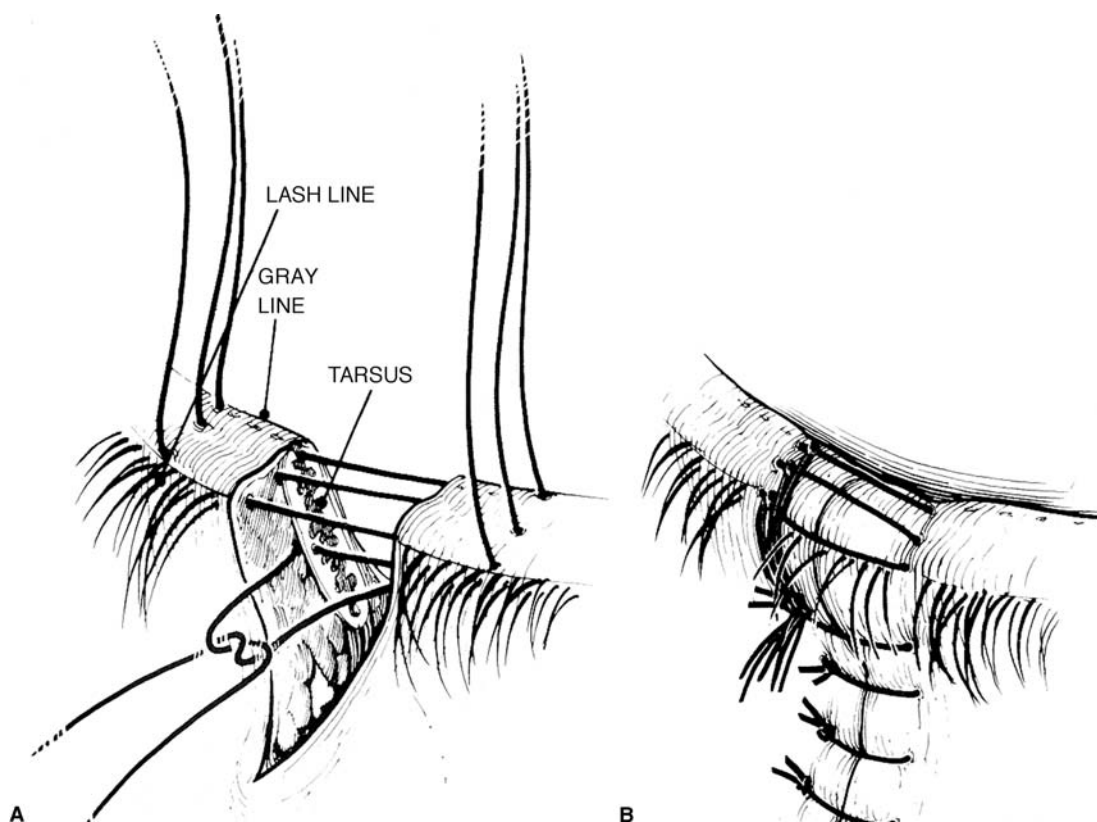


FIGURE 4-28 Repair of a marginal line laceration with sutures in the lash line, gray line, and meibomian (A and B). (From Lisman R, Spinelli H. Orbital adnexal injuries. In: Sherman JE, ed. *Surgery with Facial Bone Fractures*. New York: Churchill Livingstone, 1987:108, with permission.)

When there is loss of greater than 50 to 60% of the lower eyelid, one should consider a two-stage repair using a tarsoconjunctival flap from the upper eyelid (Hughes procedure). For larger upper eyelid defects, the Cutler-Beard procedure uses a flap that is based not on the conjunctiva but on the orbicularis muscle of the lower eyelid.

LIPS

As with the eyelid, lip lacerations often look worse than they are. Because of the tremendous vascularity in the muscle layer of the lip, significant bleeding may occur. Accordingly, careful wound analysis to locate the labial arteries should be performed so that a suture ligature may be placed. Because of the tremendous laxity of the lip, debridement to sharp wound edges is encouraged, particularly in the region in the vermilion-cutaneous junction. Classically, a suture is first placed at the vermilion-cutaneous junction. This is followed by closure of the majority of the intraoral mucosal layer. The orbicularis oris muscle is approximated with a 3-0 or 4-0 resorbable suture followed by completion of the closure of the dry portion of the red lip and securing of the vermilion-cutaneous junction. The skin is then closed with an everting suture technique. Closure of the muscle layers is extremely important to maintain sphincteric function of the lip. It is extremely rare that the upper or lower lip cannot be closed primarily. On such unusual occasions, flaps such as those described in the discussion in Chapter 2 on lip reconstruction should be consulted. The key to lip repair is precise alignment of the vermilion-cutaneous junction. Even a small mismatch becomes quite noticeable when the wound is completely healed (Figs. 4-29 and 4-30).

PEARL... Be vigorous in debridement of lip lacerations, as there is significant laxity present. Begin the repair with closure of the vermilion-cutaneous junction.

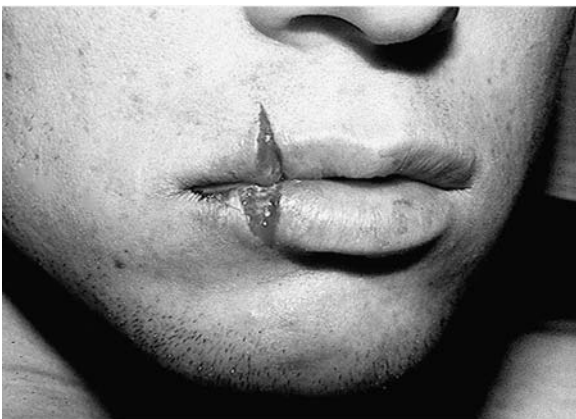


FIGURE 4-29 Laceration of both the upper and lower lips with extension through the vermilion-cutaneous junction.



FIGURE 4-30 The same patient as in Fig. 4-29 after repair. Note the good alignment of the vermilion-cutaneous junction of the upper lip but a 1- to 2-mm step-off of the scar in the lower lip.

NASAL LACERATIONS

As with the lip, it is unusual that there is an avulsion of tissue from the nose. Accordingly, although the initial wound may appear to involve a loss of soft tissue, careful cleaning and reposition of tissue will generally allow for adequate reapproximation and reformation of nasal tissues. However, it is imperative that a thorough evaluation be performed of the various structures of the nose. The nose is a composite structure with three layers consisting of the skin, the structural middle layer of cartilage in the lower half of the nose and the bony upper half of the nose, and the internal mucosal lining. Accordingly, the repair must be meticulous for each of these components. Similarly, debridement should be minimal as nasal skin tissues tend to be relatively immobile.

As with nasal reconstruction after excisions of cutaneous malignancies, adequate internal lining is necessary for survival of avulsed cartilage-containing segments. A 4-0 or 5-0 absorbable suture should be used for closure of the internal mucosal laceration. 5-0 or 6-0 sutures are then used to reapproximate cartilage lacerations to the original position. In the unusual situation where a portion of the upper or lower lateral cartilages is missing, one might consider use of a small conchal or septal graft to reconstruct the defects in the primary setting. In a situation in which structural support has been freely disrupted by the wound (Figs. 4-31 and 4-32), and where the nose has been split in the midline, structural support should be reconstituted. This can generally be created with suture techniques (such as with a dome suture), although cartilage grafts may be necessary to add support (such as a columellar strut). Finally, the skin is closed using an everting technique. In a situation of severe internal mucosal injuries, silicone splints should be placed to prevent intranasal scarring with subsequent breathing problems.



FIGURE 4-31 An upper lip avulsion continuing into a full-thickness laceration injury of the nose.

PITFALL... Many avulsion nasal injuries include significant intranasal mucosal injuries. If left untreated, synechiae may form, leading to obstruction. Accordingly, placement of silicone splints should be considered.

Small total avulsions of the nose can be treated by replacement of the avulsed segment as a composite graft. Although delayed primary reconstruction with local flaps can be attempted, such reconstructions might best be performed in a secondary setting.

EXTERNAL EAR INJURIES

Although a review of auricular anatomy is beyond the scope of this chapter, a complete understanding of the anatomy is essential for proper evaluation and treatment of external ear injuries. The intimate relationship of the skin and underlying complex cartilaginous framework is such that even small changes in the anatomy can create deformities of the ear. Accordingly, one must pay specific attention to every detail regarding anatomic relationships in external ear injuries. As a reminder, examination of the external auditory canal, tympanic membrane, and facial nerve function is also of extreme importance with respect to injuries of the external ear.

The external ear sustains all types of injuries, including abrasions, lacerations, partial and total avulsions, and hematomas. Auricular hematomas are common as a result of direct blows to the external ear (Fig. 4-6).

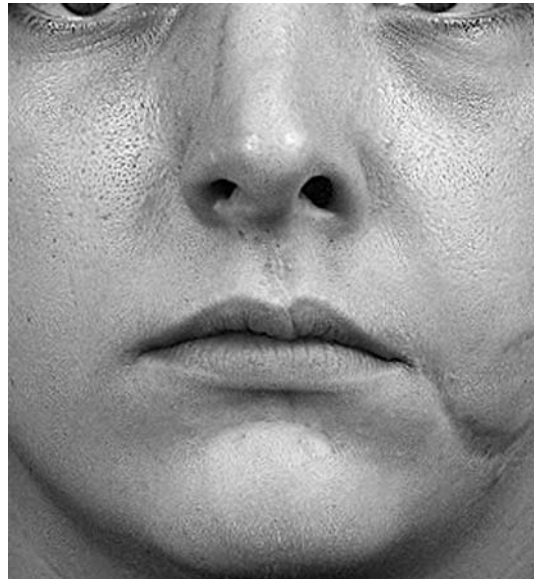


FIGURE 4-32 Six months postoperative result in the same patient as in Fig. 4-31. Note excellent restoration of the upper lip and nose after meticulous multilayer closure including reapproximation of nasal cartilages. Also, note the poor scar in the left lower cheek region, typical of superior-base avulsion flaps.

The hematoma is a subperichondrial collection of blood. It occurs due to tearing of the perichondrium from the underlying cartilage and must be treated with drainage, just as with septal hematomas. The most common sequela of an untreated hematoma is the formation of fibrosis between the cartilage and the perichondrium, which can eliminate the fine detail of the underlining cartilage. The end result is often described as “cauliflower” ear, which presents as an apparent soft tissue mass that obliterates the fine detail of the external ear. Prevention of such a secondary deformity is by evacuation of the hematoma within the first 12 to 24 hours after injury. This can be performed by aspiration of a liquefied hematoma or by placement of an incision with an anatomic landmark such as the scapha to allow for open drainage. Although further treatment is slightly controversial, in most settings a bolster is placed to close the space created by the hematoma. Generally a form of gauze with a through-and-through mattress suture provides adequate pressure to allow for healing of the subperichondrial space.

CONTROVERSY

Although traditional treatment of auricular hematomas is with open drainage followed by placement of a sutured bolster, some advocate frequent aspirations with placement of non-sutured bolsters.

TREATMENT OF LACERATIONS OF THE EXTERNAL EAR

Treatment of lacerations of the external ear is similar to treatment of those of the nose. One must remember that there are multiple layers including anterior ear skin, cartilage, and posterior external skin. Accordingly, the cartilage is apposed with small (e.g., 5-0) material followed by standard closure of the skin layers with particular attention to approximating landmarks such as the helix, scapha, antihelix, and crura. For lacerations extending to the external auditory canal, one must be concerned about scar contracture of the canal during the healing process. Accordingly, at a minimum, a wick should be placed and, in larger soft tissue injuries, a stent should be kept in place for a least 5 days after repair.

SPECIAL CONSIDERATION

With external canal injuries, stenting may limit canal scar contractures.

As the external ear protrudes away from the body, it is susceptible to avulsion types of injuries. Remarkably, it is not uncommon to see a subtotal avulsion of a segment of external ear that, after appropriate initial wound management, appears quite viable in terms of vascular supply. If such an avulsion segment appears pink in color, implying both good arterial inflow and venous outflow, reattachment of the segment followed by placement of a soft protective external ear dressing would generally result in an adequately healed external ear (Figs. 4-33 and 4-34). On occasion, an external ear segment is attached to a precariously small pedicle and it is difficult to determine either the arterial inflow or the venous outflow. If upon pinprick of the ear one notes a release of fresh (yet dark) blood, it may well imply that venous outflow is obstructed. It is in this unusual circumstance that medicinal leeches can be of extreme value.

SPECIAL CONSIDERATION

When a reattached avulsed ear segment is cyanotic yet bleeds upon pinprick, venous outflow is a likely etiology. Medicinal leeches may be of great value.

Small total avulsions of the external ear may occasionally survive as a composite graft. Protection of such avulsions using moist gauze dressing or a soft external ear (mastoid) dressing may be helpful to promote adequate healing of such avulsed wounds. In larger avulsions of the ear (if the segments are greater than $\sim 2 \text{ cm}^2$),



FIGURE 4-33 Full-thickness laceration of the upper half of the right ear. The only attachment is the skin anterior to the root of the helix (arrow). As the skin remained pink, it was sutured back together in multiple layers, including cartilaginous closure.



FIGURE 4-34 The 4-month post-repair result in the same patient as in Fig. 4-33.

decisions need to be made as to how best to manage these injuries. These large segments are unlikely to survive on their own, although primary reattachment is an option that has mixed results. Such replantation has an advantage in that no “bridges are burned” in terms of

manipulation of adjacent valuable local tissue. More aggressive treatment includes the use of two types of buried segment techniques. In the first technique the skin is completely removed from the avulsed segment and then the cartilage is sutured to its position on the remaining ear remnant. A small pocket is then created in the skin adjacent to the avulsion posterior to be followed by draping the skin over this cartilage and suturing it to the residual ear skin. After several weeks, the avulsed cartilage remnant is elevated sharply, creating a postauricular sulcus, leaving soft tissue from the mastoid region on the posterior aspect of the originally avulsed cartilage. The cartilage will generally accept a skin graft. The problem with this technique is that it results in a significant obliteration of the fine detail of the external ear.

A second technique for treatment of larger partial- or full-thickness avulsions is to attach the avulsed cartilage to its native position on the external ear remnant followed by deep dermabrasion of the skin overlying the segment. The segment is then buried deep to the postauricular mastoid skin in hopes that a vascular supply will be provided through the dermabraded skin. This technique is not commonly utilized even though successful results have been reported.

CONTROVERSY

Although there are advocates for postauricular pocket placement of ear avulsion segments, many feel that such techniques “burn bridges” in respect to saving normal skin for later use in secondary reconstruction.

Total ear avulsion presents a significant problem. This problem can be treated in one of several ways. There are several anecdotal reports of primary attachment of these segments with eventual survival. Once again, this approach has the advantage of not traumatizing the surrounding tissues, but generally only a portion of the ear survives. Another technique that has been described with limited success is complete removal of the ear cartilage framework, followed by covering of the framework with a thin vascularized tissue such as a temporoparietal fascial flap. This is then covered by a thin skin graft. Although an ear structure can be re-created with this technique, there is a predictable loss of anatomic definition. There are also several case reports of successful microvascular replantation of near-complete or complete external ear avulsions. The key to this procedure is that microvascular venous reattachment is reestablished. Although the arteries to the ear are very small, they can commonly be identified and, in skilled hands, arterial revascularization is

possible. However, venous revascularization is often quite difficult and, accordingly, if venous obstruction occurs, leeches can be used for several days until venous revascularization takes place.

Finally, in cases of subtotal ear losses, standard techniques used in ear reconstruction for oncologic defects are applicable. These include the use of a costal cartilage framework, similar to that described in microtia repairs, covered with a temporoparietal fascial flap and a skin graft.

This gives the possibility of an ear-like structure. Perhaps the best option in such cases is the use of a prosthetic external ear. Furthermore, the use of osseointegrated implants allows for an excellent, yet removable, attachment of the external ear prosthesis. Patient selection is extremely important because of the high maintenance and attention to hygiene required for such implant-borne external ear prostheses.

PEARL... Consider the use of external ear prosthesis, fixated with osseointegrated implants, for total ear avulsion.

Parotid Duct Injuries

The parotid duct has been described as exiting the anterior and superior border of the parotid gland, continuing over the masseter muscle, then abruptly turning medially toward the oral cavity. It then passes through the buccal fat pad, penetrates the buccinator muscle, and enters the lateral superior buccal sulcus as Stensen's duct just opposite the maxillary second molar. The course of the duct can be thought of as approximating a line drawn from the midtragus to the corner of the mouth.

Parotid duct injuries can be caused by a variety of injuries to the cheek region but are most commonly caused by penetrating injuries, such as in the case of broken windshield glass, a knife wound, or a penetrating bullet wound. Lacerations, particularly those orientated vertically in the midportion in the cheek, can also create a parotid duct injury (Fig. 4–35). It is likely that many parotid duct injuries are not diagnosed and are of no clinical consequence. The duct may reapproximate and become functional, or, in the case of an open laceration into the oral cavity, may fistulize into the oral cavity and reestablish function. However, it is certainly well known that a missed diagnosis of a duct injury may cause parotid swelling, salivary leaks, and even fistula formation and wound infection. The key is that there is a high index of suspicion to evaluate a wound for injury to the duct.

Diagnosis of an injured parotid duct is difficult. However, when there is a high index of suspicion, one might inject methylene blue through a silicone catheter into the duct and this might be visualized within the wound. Another less reliable method is “milking” the parotid gland forward



FIGURE 4-35 A right cheek laceration with buccal nerve branch paralysis. This wound was explored after CT scan was obtained revealing a right zygomatic fracture. The fracture was repaired along with microscopic exploration and reanastomosis of the facial buccal nerve branches. The parotid duct was explored and found to be intact.

to detect extravasation of saliva flowing from the proximal cut end of the duct into the wound.

Repair of the duct is classically described as placement of a small silicone catheter through Stensen's duct intraorally, withdrawing it from the cut distal end of the duct, and then threading it into the cut proximal end of the duct (Fig. 4-36). The small microsuture (e.g., 8-0 nylon) can be then placed to secure the cut ends of the duct over the catheter. Some controversy exists as to the length of time necessary for the catheter to remain in place. Using precise microsurgical techniques with a watertight anastomosis, the catheter probably can be removed within a week. However, the traditional literature states that it should be left in place for 3 to 4 weeks to prevent later scar obliteration at the repair site. As stated earlier, repair of the duct is probably not necessary, as reflex atrophy or, conversely, development of new drainage pathways may occur.

On rare occasions when a patient presents with late parotid swelling, salivary leak, or fistula formation, radiation therapy or even parotidectomy have been described as the treatment.

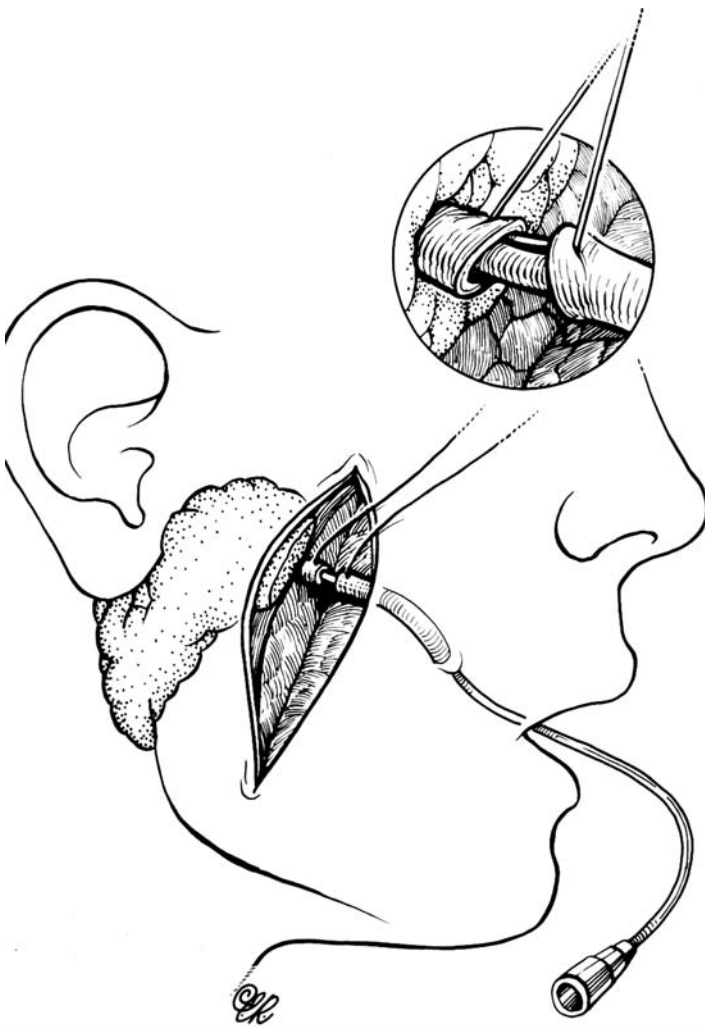


FIGURE 4-36 Identification of a lacerated parotid duct, silicone tube intubation, and repair. (From Lisman R, Spinelli H. Orbital adnexal injuries. In: Sherman JE, ed. *Surgery with Facial Bone Fractures*. New York: Churchill Livingstone, 1987:271, with permission.)

Facial Nerve Trauma

The sequelae of trauma to the facial nerve are well known. Not only can gross facial asymmetry and flaccidity be present with facial paralysis, but also the functional problems of corneal exposure, disturbances with speech and eating, drooling, and eyebrow ptosis with visual disturbance can be extremely disturbing. Accordingly, prompt recognition of potential nerve injury with facial trauma is essential. Any laceration of the lateral cheek should cause concern for the potential of a facial injury (Fig. 4–35). Accordingly, blunt probing of the wound to determine the depth of the injuries is very important. In the lateral cheek, any injury that appears to have penetrated deep to the parotid fascia should elicit concern. It is of critical importance to document facial nerve function as early as possible in evaluating the patient with a potential facial injury. Unfortunately, such documentation is commonly overlooked in the polytraumatized patient. It is common that an otolaryngologist or facial plastic surgeon is consulted regarding facial paralysis many days after the initial injury. Facial motion can be tested even in a patient who is comatose or has a grimace response to pain stimulus (e.g. knuckle pressure to the sternum).

In the cooperative patient, sequential examination of each facial nerve region should be evaluated. This would include forehead function, eyelid closure, oral commissure evaluation when smiling to determine upper lip motion, and lower lip depression. When there is partial (or regional) paralysis of the face, one should suspect direct facial nerve branch lacerations. However, when lacerations involve the earlobe and posterior cheek region, nerve trunk injury is more likely, which results in complete facial paralysis.

Immediate facial paralysis almost certainly suggests transection of the facial nerve and merits exploration with repair. Classically, it has been described that any laceration medial to a line dropped vertically from the lateral canthus involving facial paralysis does not require nerve repair. The classic thinking is that the more medial the nerve injuries are within the distal facial musculature, the more likely it is that the muscles remain at least partially innervated, thus having some potential for return of function. However, this has become more controversial and any wound lateral to the nasolabial fold associated with facial paralysis should probably be explored with an attempt to perform a neurorrhaphy.

CONTROVERSY

Although the literature often states that facial nerve injuries need not be repaired if medial to a vertical line dropped from the medial canthus, one should try to repair such injuries, if possible.

At the time of the initial presentation of posttraumatic facial paralysis, the history as to the time and origin of the trauma is very important. As stated, immediate loss of function implies complete transection of the nerve. Conversely, documented delayed onset implies a neuropraxia, which should provide good prognosis for return of function.

Unfortunately, it is not uncommon for the evaluating facial plastic surgeon to be confronted with a patient with partial or total facial paralysis in whom the onset and duration of the paralysis is unknown. In such cases electrodiagnostic tests are necessary. Such tests are useful in determining not only the integrity of the nerve but also the level of injury. Similarly, some of these tests may help in determining prognosis for recovery. It is well accepted that the facial nerve retains conductivity for about 72 hours after nerve injury. Most of the electrodiagnostic tests determine nerve injury only after this 72-hour lag period. Accordingly, one should perform the first test as soon as possible to determine baseline function.

The most common tests are facial nerve stimulation, electromyography, and electroneurography. Using a Hilger nerve stimulator, the facial nerve is stimulated near the angle of the jaw with recording electrodes in the frontalis or the orbicularis muscles. The baseline is obtained on the normal side and then on the injured side. Readings on the involved side relative to the normal side greater than 3.5 mA suggest that nerve conduction is absent and that there is degeneration and possibly transection of the nerve. The length of latency may also suggest whether there is only a contusion (neuropraxia) of the nerve or actual partial or complete transection of the nerve (axonotmesis or neurotmesis).

Electromyographic testing records muscle potentials regardless of external electric stimulation. With electrodes placed within the distal facial muscles, interferences are recorded. With no injury to the nerve, a normal facial muscle shows no electrical potentials. However, with denervation fibrillation potentials are present. After complete nerve transection, normal action potentials that are present with voluntary contraction of the facial nerve are replaced by fibrillation potentials suggestive of the degeneration. With partial nerve lacerations, fibrillation is also noted in the muscles at rest, whereas with voluntary contraction polyphasic potentials with some “giant forms” are present. This represents evidence of denervation with myopathy, as there is low voltage and an inability to recruit motor neurons on involuntary contractions, which is suggestive of a long-standing injury. Quite simply, if action potentials are not present yet fibrillation potentials exist, there is a likelihood of complete transection of the nerve. Conversely, if action potentials are present in a sudden facial paralysis, facial nerve regeneration prognosis is good, with the likelihood of good functional return.

Electromyography is of little value in early facial paralysis. It is valuable later in the recovery process, prior to clinical onset of returning visible function, and it indicates whether integrity of the nerve is present when there is voluntary attempted motion of the face.

Electroneurography (ENoG) is a well-accepted tool for electrical measurement of the facial nerve. Maximal facial nerve stimulation is provided at the stylomastoid foramen and the amplitude of potentials are measured and recorded as a percentage of the unaffected side. The assumption is that the percentage is proportional to the number of degenerated fibers of the affected nerve. As opposed to electromyography, it has been determined that there is only about a 24-hour delay in ability to detect degeneration. It has been suggested that if 90% or greater degeneration is measured by ENoG, severe facial asymmetry and deformity result. Accordingly, if 90% or greater degeneration is measured by ENoG, a transection of the nerve is likely. Similarly, in presence of a temporal bone injury, this measurement is highly specific for an intratemporal bone facial nerve injury.

The use of such electrodiagnostic tests continues to be controversial, and therefore clinical judgment remains the most important component to this process. Accordingly, any laceration in the posterior cheek associated with facial paralysis, particularly if it is oriented vertically, probably merits formal exploration. Such exploration can be performed through the laceration if it is large enough. Otherwise, the laceration can be combined with a standard parotidectomy incision (Fig. 4-37). The main

trunk of the facial nerve is identified using standard anatomic landmarks. This dissection is particularly important in lateral facial lacerations. In more anterior cheek lacerations, exploration through the wound may be more appropriate, identifying the nerve branches in retrograde fashion. In the more posterior cheek lacerations, after the main trunk of the nerve is identified, an attempt is made to find the distal portion of the nerve. In this situation the use of a nerve stimulator can be extremely useful for identifying the distal main trunk of the nerve. Once the severed trunk or branches are identified neurorrhaphy is performed. If possible, the nerve ending is carefully freshened with a sharp scalpel blade and the nerve repair begun. Most surgeons prefer an epineural repair using a small nonabsorbable suture (e.g., 7-0 or 8-0 nylon). Atraumatic technique should be utilized and the nerve should be repaired with minimal or no tension. If significant tension is noted during the repair, placement of an interpositional nerve graft should be considered. If such an interpositional nerve graft is required, the optimal donor nerve is that of the great auricular nerve, harvested as it surfaces over the posterior aspect of the sternocleidomastoid muscle. The graft is interposed and similar epineural neurorrhaphy is performed.

PITFALL... Nerves that are repaired under tension tend to do poorly. When in doubt, use a nerve graft.



FIGURE 4-37 A deep preauricular laceration with traumatic facial paralysis. The forceps is holding the cut distal to the extratemporal facial nerve.

In patients with facial nerve injuries, with or without neural repair, adjunctive measures should be considered. In particular, eye protection is extremely important. In a younger patient with facial paralysis, adequate eye closure and protection is generally present due to the excellent tone of the eyelid margin and skin. However, in older patients, laxity of these structures may lead to immediate or delayed inability for the patient to protect the eye. Accordingly, corneal protection is initially obtained by placement of specific ointments, and one may consider reversible procedures such as upper lid loading with a gold weight and lower eyelid tightening. Although these procedures are rarely necessary, they can be extremely helpful to the patient. If at all possible, one should avoid tarsorrhaphy as it necessarily blocks vision in the involved eye.

PEARL... Do not hesitate to perform early eyelid surgery even if there is a good prognosis for functional return. If there is symptomatic corneal exposure, placing a gold weight on the upper lid and lower lid tightening procedures are extremely helpful.

Patients with facial nerve injury should be counseled for long-term follow-up. Regeneration and return of function can take a minimum of months and a maximum of several years, and patients should be informed of this. Psychological counseling and active physical rehabilitation are the rule rather than the exception in these cases.

SOFT TISSUE INJURY FOLLOW-UP

Patients with soft tissue injuries of the face often need long-term follow-up, as was discussed with facial nerve injuries. Because of the blunt and macerated nature of many soft tissue injuries, suboptimal scarring certainly can occur. It is important during the early phases of wound healing to counsel the patient in terms of the length of time one should expect before there is final wound healing. In young children this can be as long as 18 months. Conversely, in an elderly patient with significant skin damage, this healing can be as short as 3 months. Secondary scar revisions should be planned accordingly. Although it has been stated that one should wait for an extended period of time prior to performing scar revision, each individual situation dictates when this is appropriate. The surgeon should wait at least until the inflammation phase has passed, but it does not mean that complete scar maturation is required prior to revision. The latter is particularly the case in the patient who has a significantly inverted scar, particularly if there is an adverse psychological impact.

Another modality that should be considered in the early phase of wound healing is dermabrasion. Particularly in an irregular wound, dermabrasion at between 4 and 8 weeks postrepair can optimize wound healing and possibly preclude the need for later scar revision.

CONTROVERSY

Although it is often stated that scar revision should be delayed until there is total scar maturation, it can be performed sooner in some cases of severe deformity, especially if the scar creates functional problems.

FACIAL FRACTURES

BASIC PRINCIPLES

The treatment of craniomaxillofacial fractures throughout the 20th century has evolved from closed treatment of fractures to the use of interosseous wire fixation and the use of external devices. Although first described in the 1960s, the use of internal fixation did not increase in popularity until the late 1970s to 1980s, and it has really been only in the past 15 to 20 years that plate and screw

fixation has gained universal acceptance. The evolution has been toward refining the metallurgy as well as developing different shapes, sizes, and malleability of the plates. More recently, resorbable plates and screws have gained some acceptance. It is quite likely that other forms of fixation such as rivets and tissue glues may well find a place in treatment in trauma.

This section briefly reviews bone healing principles, the basic principles of facial plating, and the surgical approaches to the craniomaxillofacial skeleton.

BONE HEALING

Healing of bone throughout the body depends on reduction and stabilization. Not unlike the skin, bone has an innate ability to heal regardless of the stabilization technique utilized. Accordingly, bone healing can be guided by external casts, splints, external fixation devices, or internal fixation devices. Most commonly, there is at least some motion ("micromotion") at the fracture site. The initial inflammatory response of healing is followed by the formation of a callus, which stabilizes a fragment, then allows osteon growth across the fracture defect such that the fracture site is bridged by new bone. The basic principles of stabilization of fracture fragments allows this process of callus formation and eventual replacement by solid bone to occur. Accordingly, it behooves the surgeon to optimize the bone healing with an appropriate type of fixation for each fracture. This does not mean that internal or external devices are required for all fractures, but it does require the basic understanding of which fractures are most likely to heal most optimally with different types of techniques.

There are two basic types of fracture healing that should be understood. The first type is indirect bone healing, in which, as described above, callus formation occurs with ingrowth from the surrounding fracture site of vessels and fibroblasts into the fracture hematoma. The callus formation of fibrous tissue converts eventually to a fibrocartilage, and, finally, to the ingrowth of osteoblasts, which lay down an osteoid compound resulting in this callus formation. Eventually, osteons grow across this area, resulting in remodeling, which completes the healing process with newly formed bone. As mentioned, indirect bone healing is by far the most common type of bone healing. Bones usually heal very adequately with indirect bone healing. However, because this type of healing requires a longer period of time and, by its very nature, has at least some bony motion associated with it, there is a slightly increased likelihood that excessive mobility may lead to nonunion and even infection.

The second type of bone healing is that of direct bone healing, and this type is ideal in that bone fracture ends have been reduced to the greatest degree possible by the placement of rigid fixation. As we will discuss, this

generally implies a compressive type of fixation. The difference from indirect bone healing is that in direct bone healing bone remodeling and healing begin immediately with the proliferation of osteons growing across the fracture site with proliferation of haversian canals. The osteons can be thought of as forming pegs that create early bone stability during the ultimate remodeling process. Critical to direct bone healing is the absolute rigidity required to prevent any micromotion during the healing process. Once micromotion occurs, the healing type is converted to indirect bone healing as a gap formation has occurred. Similarly, it should be understood that although idealistically an environment could be created with absolute reduction and compression across the fracture line, which result in complete direct bone healing, the reality is that not all areas are under compression, and gap healing will occur for a significant portion of any fractured bone. Thus, although direct bone healing is more efficient than callus formation or indirect healing, the speed at which most bones heal is no different whether compression is used versus other types of internal fixation. In other words, from a practical perspective, although direct bone healing does not involve intermediate stages of tissue differentiation, it is not faster than indirect bone healing with callus formation.

PRINCIPLES OF FIXATION AND PLATING

The techniques and options for plating of various facial fractures are reviewed below in more detail for each facial bone region. However, it is important to understand several principles of plate and screw fixation prior to proceeding. Stated simply, successful fixation of fractures requires basic knowledge and application of biomechanical principles, which direct us toward appropriate types of internal fixation techniques for particular fracture scenarios. To obtain stability across the fracture site, a fixation device must be appropriate for the anatomic and physiologic needs, including the amount of functional load placed across each particular fracture.

As stated by many authors, fixation techniques for bone repair are based on several principles and premises. A screw must be of proper length and design to withstand pressure placed upon it in the bone over time. A plate must impart enough strength and rigidity over a fractured bone so that when it is fixated with screws it will remain fixed together despite full loading across the fracture site during functioning. Accordingly, the plate must be properly designed and positioned to withstand these forces. A greater number of fixation points will generally yield a better fixation. Finally, in a situation where a gap of bone is present across the fracture site, such as in a comminuted fracture or a fracture with avulsion of bone, the fixation device must be of adequate strength to support a functional load across this gap.

PITFALL... A lack of understanding of basic biomechanics can lead to inappropriate use of fixation devices, which, in turn, will lead to failure.

Prior to discussing the biomechanics of fractures, which entail the use of certain types of plates and screws, it is worth reviewing the terminology used for plates and screws. Unfortunately, there is no standardization of terminology among manufacturers, but the most common way to describe a plate within a particular type of plating system is by the screw size. The screw size is described by the width of the screw threads. Accordingly, a 2.0 plate can generally be thought of as a plate designed to be of adequate size and design to accept a matching design of a 2.0-mm thread within a screw. Once again, even within one manufacturer's plating set, there may be a great variety of different types of 2.0-mm plates providing different strengths and malleabilities. Some plates may be somewhat thicker, to maintain functional loads within the mandible, whereas others may be thinner and more malleable yet strong enough to maintain a functional load across the buttresses of the midface in the maxilla. In general terms, the smallest plate that one generally finds in a system is a 1.0-mm plate with a 1-mm thread width screw. Conversely, the largest plate is that which has been designed to withstand the forces of the mandible across the bony gap. These larger plates and screws vary significantly from one plating system manufacturer to another but generally range in size from a 2.4-mm to a 3.5-mm thread width screw.

PEARL... The size of a plate is usually designated by the thread width size of the screw for which the plate has been designed (e.g., a 2.0 plate holds a 2.0-mm screw).

Simply stated, when there is no loading force across a fracture line, a very small fixation device can be used. An excellent example of this is a comminuted fracture of the frontal bone, where all that is required is basic reduction of the fracture. In this situation, as there is a limited force placed across the fracture sites, minimal fixation is needed, and, accordingly, interosseous wire fixation or "microplates" (1.0- or 1.3-mm design) provide adequate fixation. In the future, these types of non-load-bearing fractures may possibly be repaired with tissue glues or other nontraditional forms of bone plates.

As one progresses down the maxillofacial skeleton, mastication places functional loads on the facial bones and, accordingly, plates of greater strengths are required. Controversy exists as to what is adequate fixation with various fractures of the maxilla and mandible.

The different shapes, sizes, malleabilities, and strengths of plates that are provided in each plate manufacturer's set compound the problem of determining adequate fixation. Surgeons should become familiar with the biomechanical properties of the plates in each system that they will be using.

As will be discussed in each specific fracture type, there is an absolute minimum type of fixation that can be applied to provide adequate rigidity and fixation. Conversely, one might consider using a larger, excessively rigid plate. The advantage of such a rigid plate is that it will most likely be able to withstand greater functional forces. However, as plates and screws become larger, they often are more difficult to apply, require greater exposure of soft tissues (which may in and of itself create more morbidity), and finally may create a situation in which the fixation device is palpable or visible through the soft tissues. Thus, the plate and screw size should be chosen to optimize the chances for bone healing across the fracture site while at the same time minimizing technical difficulties and morbidity.

Most plates that are positioned across the fracture line can be considered "adaptation" plates. These plates are adapted across a fracture that has been adequately reduced. In this scenario, the adaptation plate can be either very small (e.g., 1.0-mm size) or much larger (e.g., 2.4-mm size) depending on the functional load across the fracture. As no compressive forces are applied, indirect bone healing should occur. Once again, the plates must be of adequate strength and size to allow no more than micromotion across the fracture line. Accordingly, a plate of any size and strength can be used in a non-load-bearing region, whereas a plate of adequate strength and size must be utilized where any functional load is present, such as maxillary buttresses or in the mandible.

Compression devices are required for direct bone healing, and they presented the mainstay of treatment for the initial understanding of fracture fixation, biomechanics, and bone healing. The dynamic compression plates initially described by the AO/ASIF (Association of the Study of Internal Fixation in Switzerland) and by Professor Hans Luhr in Germany represent the classic compression device. Fig. 4-38 demonstrates the dynamic compression plate (DCP) principle. Fig. 4-38 (top) represents the placement of screws through a plate across the fracture line without compression. A gap remains within the fracture segment, which will lead to indirect bone healing. Fig. 4-38 (bottom) demonstrates how dynamic compression is achieved. The screw holes are designed such that there is a gliding slope on its outer aspect. When a screw is placed eccentrically (away from the fracture line) in this hole, the head of the screw slides downward toward the fracture. As this process occurs, the engaged threads of the screw then force the bone toward the fracture line. This implies a compressive force of the engaged segment of bone into the opposite fracture

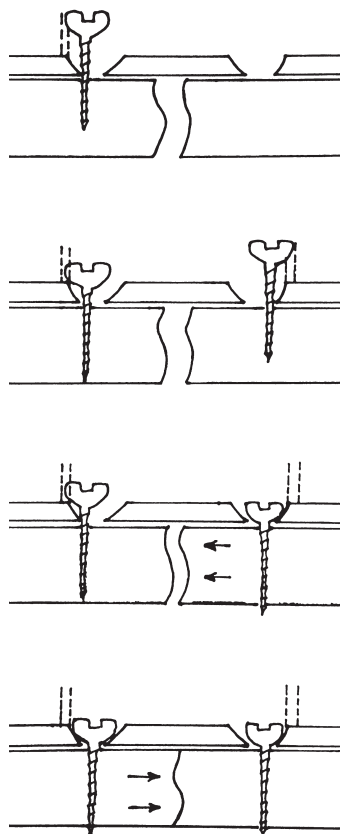


FIGURE 4-38 The mechanism of action of a dynamic compression plate. The first screw is placed eccentrically (away from the fracture line) and screwed into the bone until the head of the screw touches the plate. A screw is then placed in the first hole on the opposite side of the fracture in an eccentric fashion. This screw is completely tightened, which produces movement of the bone on the contralateral side toward the fracture line. Finally, the first screw is tightened on producing further movement of the screw toward the fracture line with compression being accomplished. (From Kellman R. Principles of facial plating techniques. In: Papel ID, Nachlas N, eds. Facial Plastic Surgery. Chicago: Mosby Year Book, 1992:460–475, with permission.)

fragment. This compression is magnified by placement of a corresponding screw on the opposite side of the fracture fragment in a similar compressive mode. Theoretically, this applies direct contact across the fracture line and leads to direct bone healing. As stated previously, small gaps will persist despite this compression, but there will still be direct bone healing throughout much of the fracture site. This type of compression requires fracture segments that are close to perpendicular to the surface of the bone.

If the fracture is oblique, as the fragments may overlap when they are compressed at the surface, they may glide over each other, resulting in malposition. Accordingly, a dynamic compression plate should only be utilized in areas where there is adequate bone thickness as well as in fractures that are perpendicular to the outer bony surface.

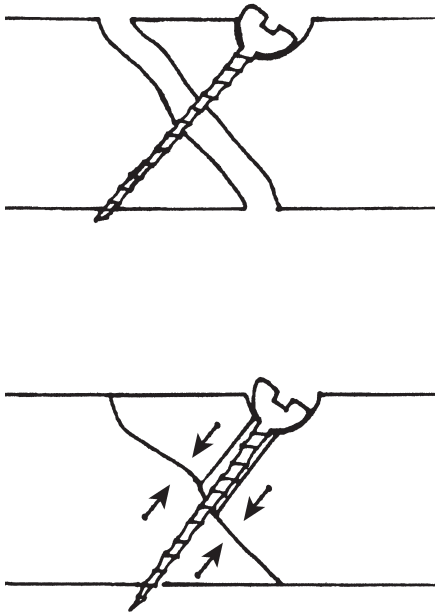


FIGURE 4-39 Top: The principle of a position screw. A hole is drilled of the appropriate size for the screw thread width (i.e., smaller) through both the outer and inner cortex of bone across the fracture line. The screw threads engage both cortices of bone and no compression is produced. Bottom: A hole is drilled in the proximal cortex of bone that is larger than a screw thread width. Accordingly, the hole is “inactivated” with the threads gliding through it without engaging the bone. However, the screw threads engage the distal cortex of bone and as it is screwed in position and the head of the screw recedes into the countersink of the proximal segment, compression is produced at the fracture line. (From Kellman R. Principles of facial plating techniques. In: Papel ID, Nachlas N, eds. Facial Plastic Surgery. Chicago: MosbyYear Book, 1992:460–475, with permission.)

SPECIAL CONSIDERATION

Although dynamic compression plates were the workhorse fixation devices for fixation of mandibular fractures in the past, they are less frequently utilized today.

When oblique fractures are present and compression is desired, compression must be perpendicular to the oblique fracture line. This can be obtained by placement of a screw using the lag screw principle, the basic premise of which is that by properly placing the screw perpendicular to the fracture fragment interface, compression will be applied. The key is using the proper sequence for application of this compression (Fig. 4-39). If an appropriate size hole is drilled for the screw being used across the oblique fracture line (e.g., a 1.5-mm hole for a 2.0-mm screw), when the screw is placed the threads will engage both the proximal and distal fragments of bone. In this scenario, as the head of the screw engages the bone, no further compression will be placed across the fracture fragment

interface. This is called a “position” screw. To obtain compression, the screw must glide through the proximal segment without the screw threads engaging the bone. Accordingly, a hole must be drilled in the proximal fragment of bone that is the same size or larger than the screw width (e.g., a 2.0-mm hole for a 2.0-mm screw). In other words, the screw threads are “inactivated” in the proximal fragment of bone. An appropriate size hole is drilled in the distal segment of bone that allows for engaging of the screw threads in this fracture fragment. As the screw is placed, the threads engage the distal fragment of bone, and, as the screw head engages the proximal bone segment surface, compression is applied across the fracture fragment bony interface. Creation of a “countersink” to allow the screw head to fit into the outer bone segment is very important. This allows two processes to occur. The screw head glides into a prepared concave surface and applies an even force to that surface without fracturing the bone. It also allows maximal compression of the screw head against this outer fragment of bone. Lag screws can be placed either independently as a sole fixation device or obliquely through a plate to add additional support to an adaptation type of plate.

The final type of fixation device to be discussed is the reconstruction plate. Once again, each plating manufacture has different names and designs for these plates, but each is designed to provide fixation of adequate strength and rigidity to bear an entire function load across the bone gap. Accordingly, the most common place where this occurs is in the mandible. The common scenarios where a reconstruction or “bridging” plate is required include a comminuted fracture of the mandible or a fracture in which a segment of bone is missing, such as in a gunshot wound. There are two types of reconstruction plates. The first is a large adaptation design that relies on the compression of the screw head against the plate to maintain the fixation of the plate and to bear the load across the fracture. In the second design, the head of the screw actually engages both in the underlying bone as well as into a prethreaded screw hole of the plate itself. In this design, the plate can be thought of as an internally positioned “external fixator.” In other words, the strength of the adaptation design is dependent on its fixation of the plate to the underlying bone, whereas the “locking screw” plate is less dependent on the interface of the plate with the underlying bone, but rather is very dependent on the intimate contact between screw threads in the bone and the head of the screw locking into the plate.

SURGICAL APPROACHES

Along with the evolution of more sophisticated methods to treat facial fractures has come an evolution in surgical approaches. Many traditional approaches continue to be used, but their indications have been refined. The current

trend is toward the use of incisions and approaches that produce the least amount of morbidity. Accordingly, the movement is away from transcutaneous incisions in lieu of transmucosal and hidden incisions. With the advent of endoscopic approaches in cosmetic surgery has come the realization that these approaches may also be useful in the treatment of facial fractures, thus decreasing morbidity even further. However, such endoscopic approaches are still evolving and will not be discussed in this chapter. Several references that provide definitive detailed explanations for each surgical approach to the maxillofacial skeleton are provided in the suggested readings list at the end of this chapter. However, we briefly review all pertinent approaches here.

With respect to fractures of the mandible, the trend is toward intraoral incisions whenever possible. The symphyseal and parasymphyseal regions as well as the anterior and midportions of the mandibular body can be approached through a buccal sulcus intraoral incision. There are four important anatomic considerations when performing this incision. First, the mucosal incision should be placed onto the labial mucosa above the sulcus. As this incision heals it will contract into the sulcus. Conversely, if the incision is made in the deepest portion of the sulcus, there will be contraction and vertical shortening of the sulcus in its vertical dimension. This is particularly a problem in patients who wear dentures. Second, appreciation of the mentalis musculature is important. This muscle provides protrusion of the lower lip and, if not properly reattached, can lead to a laxity of the lower lip. Accordingly, at the time of closure the severed muscle ends should be reapproximated with a 3-0 resorbable suture. Third, the location of the mental foramen and its exiting mentalis nerve, an extension of the inferior alveoli nerve, must be taken into account. Injury to this nerve causes a bothersome numbness to the lower lip and chin region. Fourth, one should determine the length of the tooth roots in this region so that they are not penetrated when placing screws.

PITFALL... If the mentalis muscle is not reapproximated at the time of closure, there is a chance that an unsightly lower lip ptosis may occur.

With these anatomic considerations in mind, an incision is made through the mucosa several millimeters onto the labial portion of the gingival mucosa. This is commonly made with scalpel blade followed by electrocautery to incise through the mentalis muscles down to and through the periosteum. As the mental foramen has been described as being located between the two premolars or directly below the posterior premolar, dissection in this region should be performed with a fine-tip hemostat spreading bluntly in a vertical direction until

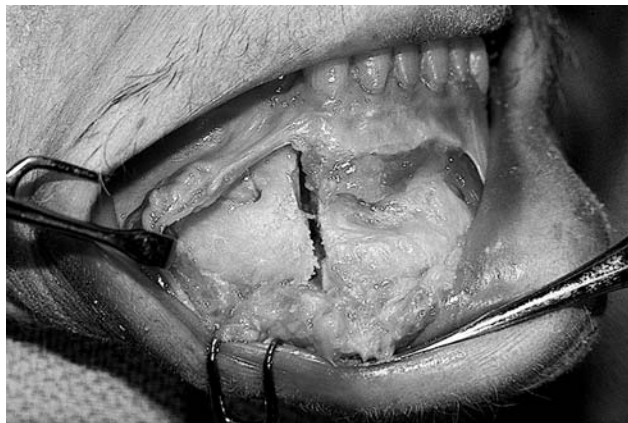


FIGURE 4-40 Dissection of a right parasymphyseal fracture. Note the protected right mental nerve.

the fibers or the mental nerve are isolated. Sharp dissection can ensue around these fibers down through the muscle and submucosal tissue to and through the periosteum. The periosteum is then elevated throughout the mental region to the inferior border of the mandible (Fig. 4-40). Lateral subperiosteal dissection continues until the mental foramen nerve is clearly identified. From this point forward the nerve should be protected by gentle retraction. Once again, it is important to reapproximate the mentalis muscle with a large absorbable suture following fracture repair.

PEARL... The mental nerve can be identified by gentle, blunt, vertically oriented dissection with a fine-tip hemostat in the region of the premolars.

Fractures of the anterior and midbody of the mandible can be approached through an extension of this incision. However, exposure becomes more limited because of the presence of the mental nerve. The incision is often carried posterior to the molar region to allow for adequate reflection of tissues to limit the amount of tension placed on the mental nerve.

The parasymphyseal region can also be approached externally through an extraoral incision. This incision is rarely made unless it is in association with multiple other comminuted fractures in the mandible, thus requiring placement of a large reconstruction plate. Extraoral exposure of the symphyseal and parasymphyseal regions is achieved by placement of a horseshoe-like incision inferior to the anterior aspect of the mandibular border, preferably in a preexisting skin crease. Dissection is continued through the platysma muscle to the attachment of the suprahyoid musculature at the inferior mandibular border. The incision continues through the periosteum and the mandibular fracture is identified. After fixation,

the muscle layers should be reapproximated. This type of approach often requires external drainage, because of the extensive soft tissue dissection.

The angle region can be approached with a transmucosal incision directly over the external oblique ridge extending onto the mandible just anterior to the molar region. Once again it is important to leave at least a 5-mm cuff of mucosa away from molar dentition. Cautery dissection through the submucosal tissues to the periosteum is performed followed by subperiosteal dissection and exposure of the fracture site (Fig. 4-41). The periosteum may be elevated to the inferior border in the angle region and to the posterior border of the ascending ramus. To have adequate exposure, specially designed retractors are extremely helpful in that they can be placed and locked underneath the angle of the mandible and posterior border to allow improved exposure. It should be noted that if a single plate is being placed along the external oblique ridge superiorly, more aggressive dissection may be harmful, as it has been suggested that the buccal cortex periosteum may impart a significant portion of the blood supply to the mandibular angle bone. Upon completion of the fracture repair, the soft tissue should be closed in two layers using resorbable sutures.

Exposure to the mandibular angle as well as the posterior body and ascending ramus can be performed through a submandibular neck incision (Fig. 4-42). This incision is traditionally placed at least two fingerbreaths inferior to the mandibular border. From an aesthetic standpoint, it is perhaps more important to place this incision in a natural skin crease, if present. However, the incision tends to extend more inferiorly as it proceeds anteriorly. Sharp dissection through the platysma followed by superior dissection in the subplatysmal plane is performed. The superficial layer of the deep



FIGURE 4-41 Intraoral exposure of a right angle fracture after subperiosteal dissection of this region. As is shown here, a transcutaneous trocar placement with lip retractor facilitates the dissection and repair.

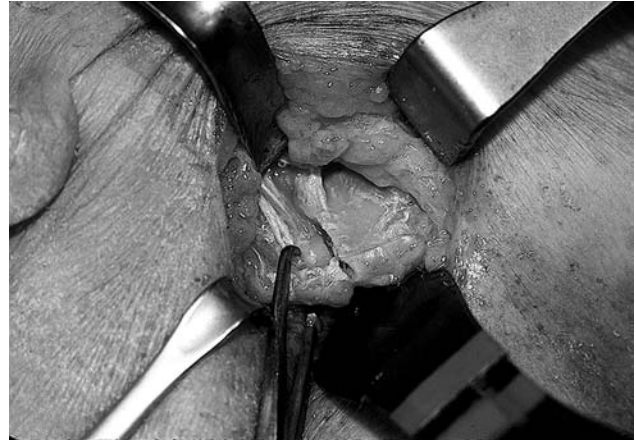


FIGURE 4-42 Extraoral approach to a left angle fracture.

cervical fascia is carefully incised followed by identification, dissection, and ligation of the facial vein (and, occasionally, the facial artery). By retracting the tissues lateral to this vascular structure, the marginal mandibular branch of the facial nerve should be protected. Conversely, the marginal mandibular nerve can be identified and retracted superiorly and laterally under direct vision. A nerve stimulator can be very helpful with this technique. The mandibular angle and posterior body are identified and the periosteum is incised along with the inferior border. The incision should be at the inferior border at the mandible because it tends to be the least vascular where the masseter and pterygoid muscles insert. Retraction allows for identification and reduction of the fracture. In fractures of the ascending ramus and low subcondylar neck fractures, placement of a sigmoid notch retractor can be very useful to retract the masseter muscle. After reduction and fracture repair, the pterygo-masseteric sling is closed with an absorbable suture followed by closure of the subcutaneous tissue and skin. A drain is often placed in this incision. For improved exposure when approaching low subcondylar fractures, this incision may be extended posteriorly and superiorly.

PEARL... Although ideally the marginal mandibular nerve is identified, retraction of the ligated facial vessels should allow for protection of the nerve.

Until the endoscopic approaches to the subcondylar region are perfected, acceptable currently utilized techniques include the retromandibular and periauricular approaches. The retromandibular approach uses a vertical incision posterior to the angle of the mandible followed by dissection through the subcutaneous tissue, the subcutaneous musculoaponeurotic system (SMAS), and

the parotid capsule after having undermined it with a hemostat. Blunt dissection through the parotid gland by spreading in the direction of the fibers of the facial nerve creates a small surgical window to the posterior mandible. Retraction of tissues between the inferior and superior divisions of the facial nerve allows visualization of the subcondylar region. Attention is turned to the inferior portion in the incision where the pterygomasseteric sling is incised after retraction of the inferior division of the facial nerve. This allows for access to the ascending ramus of the mandible.

To approach the condylar region itself, a preauricular approach can be utilized. In this approach, dissection of the zygomatic arch is performed at the level of this superficial layer of the temporalis fascia and below the zygomatic arch along the tragal cartilage. The elevator is placed beneath the superficial layer of the temporalis muscle, stripping periosteum off the lateral portions of the zygomatic arch. Below the arch, elevation is just superficial to the capsule of the temporomandibular joint. The superior division of the facial nerve should be lateral to this elevation. The alternative to these approaches is the facelift approach, which essentially combines the preauricular and retromandibular approaches.

One of the most valuable transmucosal approaches is the sublabial (transvestibular, transbuccal) approach to the maxillary midface. Exposure to the entire maxilla, nasal base, and even to the inferior aspect of the infraorbital rim can be gained through this approach. Visualization of the medial and lateral buttresses of the maxilla is important in the treatment of midface (or Le Fort-type) injuries as well as in the repair of zygomatic fractures. Key considerations in this approach are, once again, preservation in an adequate mucosal cuff for maintenance of an adequate upper buccal sulcus and refraining from injury to the infraorbital nerve. The latter exits from the infraorbital foramen immediately below the infraorbital rim. This nerve location is relatively inferior and must be identified early in the dissection process.

The upper buccal sulcus incision is begun with an incision through the mucosa on the labial portion of the upper lip, using sharp dissection or electrocautery. One then proceeds through the submucosal tissues to the inferior maxilla, entering the periosteum at the level of the tooth roots. After entry through the periosteum onto the face of the maxilla, attention is turned toward exposure of the medial and lateral buttresses (Fig. 4-43). It is common that the thin bone over the maxillary sinus is comminuted, which makes the dissection and identification of structures, particularly the infraorbital nerve, more difficult. Sweeping of periosteum from lateral to medial and medial to lateral generally avoids injury to the nerve even if it is not completely identified. Depending on the situation, the buccal sulcus incisions can be unilateral, bilateral, or transvestibular, such as in the case of a severely comminuted bilateral midface fracture. The latter approach allows



FIGURE 4-43 Upper buccal sulcus approach to the maxilla and midface.

excellent exposure to the entire maxilla and, when combined with a classic midfacial degloving approach with the release of nasal tissues, exposure of the infraorbital rim is easily within reach. The facial degloving approach is not generally recommended, but in severe avulsion injuries the vestibular portion of the nasal base may be avulsed and the incision is essentially already performed. Following reduction and fixation, the wounds are irrigated and closed with subcutaneous absorbable sutures and a running closure of the buccal sulcus incision.

PEARL... When approaching the midface via a buccal sulcus incision, injury to the nerve may be infraorbital, which can be avoided by focusing subperiosteal dissection along the medial and lateral buttresses.

A lower eyelid approach is necessary for the inferior orbital rim, lateral orbital rim, and internal orbit. The two most popular approaches involve subciliary and transconjunctival incisions. The subciliary approach has the advantage of providing excellent exposure to the entire orbital floor and lower aspect of the medial orbital wall but it allows only limited exposure to the lateral orbital wall. The main risk of the subciliary is the potential risk of an ectropion. In this approach the incision is made immediately inferior to the lower eyelid lashes, with the initial dissection through the skin and subcutaneous tissues (Fig. 4-44). A small amount of dissection ensues on the surface of the orbicularis oculi muscle followed by a sharp incision through the muscle onto the orbital septum, which is followed to the infraorbital rim. The periosteum is incised, followed by dissection of the orbital floor and walls, at which time the extent of the orbital floor and wall fractures is determined. As will be discussed, it is important to locate solid bony ridges in the posterior orbit to facilitate proper reconstruction (Fig. 4-45).

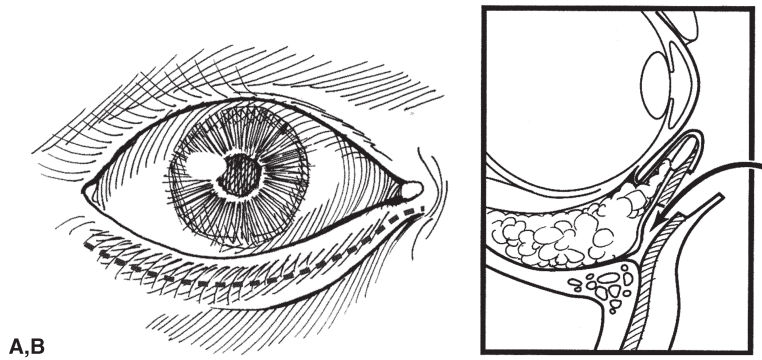


FIGURE 4-44 (A,B) Lower eyelid subciliary approach to the orbit.



FIGURE 4-45 Dissection demonstrating the infraorbital rim, fractured orbital floor, and residual bony ledges in the posterior orbit.

As with all incisions and approaches, meticulous sharp dissection is the key to minimizing trauma to the lid structures. It is important at the time of closure to reattach the suborbicularis soft tissues by suspension of

these tissues to the orbital rim absorbable suture. Similarly, suture suspension of the skin muscle flap to the region just lateral to the lateral canthus can be useful to prevent ectropion.

The transconjunctival approach has the advantage of excellent exposure to the lateral orbital rim and orbital wall, particularly if a canthotomy is performed. Smaller, isolated orbital floor fractures may sometimes be repaired without a lateral canthotomy. If a canthotomy is required for adequate exposure, it is performed by making a horizontal incision directly through the lateral canthus (lateral canthotomy) extending laterally 5 to 10 mm into the “crow’s foot” (Fig. 4-46). An inferior cantholysis is subsequently performed to release the lateral aspect of the lower eyelid. Following these lateral canthal-releasing maneuvers, the transconjunctival incision is made inferior to the lower lid tarsal plate. This can be performed with scalpel, scissors, or a fine needle tip cautery on a low power setting. After incision through the conjunctiva, sharp dissection ensues through the orbital septum to enter onto the anterior aspect of the orbital septum. At this point, the approach to the infraorbital rim is similar to that of the subciliary approach. Dissection may then take place along the lateral orbital rim to approach the

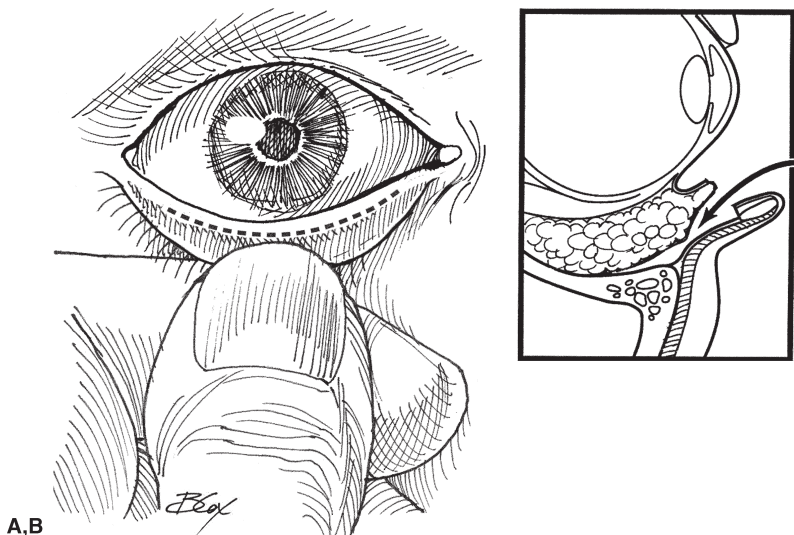


FIGURE 4-46 (A,B) Transconjunctival approach to the orbit, with a lateral canthotomy and cantholysis, conjunctival incision, and dissection back through to the anterior surface of the orbital septum.

frontozygomatic fracture and lateral orbit wall. In either of these eyelid approaches, the goal is to define the orbital rim fractures as well as the extent of the internal orbital fractures (Fig. 4–45). An elevator is utilized to dissect out the prolapsed orbital contents and define the solid bony ledges in the posterior aspect of the orbit.

CONTROVERSY

When using the transconjunctival approach, the orbital rim can be identified by either incising directly through the fornix or proceeding below the tarsal plate through to the anterior surface of the orbital septum. Theoretically, the orbital fat will be avoided with the latter approach.

If a lateral canthotomy/transconjunctival approach has not been used, a brow or upper eyelid crease incision must be made to approach the frontozygomatic fracture and lateral orbital fracture. Although the brow incision is commonly used, a more cosmetic approach is the lateral “blepharoplasty,” whereby an incision is made through the upper tarsal skin crease followed by retraction of the incision over the lateral orbital rim (Fig. 4–47). Using a needle tip cautery on a low setting, the subcutaneous tissues, orbicularis oculi, and the periosteum over the lateral orbital rim can be incised. At the time of closure, the periosteum is closed over the orbital rim and a fine absorbable suture is used for closure of the skin.

PEARL... When approaching the frontozygomatic fracture, use an upper tarsal crease incision instead of a brow incision to optimally hide the scar.



FIGURE 4–47 Upper tarsal crease incision and approach to the lateral orbital rim.

The final approach to be discussed is the coronal approach to the frontocranial, temporal, zygomatic, and lateral superior midface regions. This approach has the advantage of excellent exposure of the aforementioned areas, but has the disadvantage of creating a large scar across the top of the head and obligatory numbness to the central scalp. Other potential complications include paralysis of the frontalis muscle because of injury to the frontotemporal branch of the facial nerve. To avoid the latter, one must have an excellent understanding of the pathway of the frontal branch of the facial nerve through the temporal fascial layers. The reader is referred to articles on this topic in the suggested readings at the end of the chapter. Suffice it to say that the frontal branch crosses the zygomatic arch within the temporoparietal fascia and then penetrates the deep surface of the frontalis muscle. The temporoparietal fascia is superficial to the loose areolar plane, which overlies the denser temporal fascia (superficial layer of the deep temporal fascia).

Other important anatomic considerations with the coronal approach include avoidance of injury to the supraorbital neurovascular structures as they exit from the supraorbital foramen (or notch) and consideration of preservation of the pericranial flap for use in frontocranial fractures. Regarding the latter, the decision about which plane of dissection to use to approach the supraorbital rim should be made prior to incision. If a pericranial flap is required, it should be carefully preserved during the dissection.

SPECIAL CONSIDERATION

When an anterior skull base fracture is present, a pericranial flap should be preserved for later use.

The traditional description of the coronal approach involves a curvilinear incision from one root of the helix to the other. However, the author prefers a zigzag (W-pasty) incision that ultimately better camouflages the scalp incision. The incision is made down through the galea to the periosteum centrally, as well as to the deep temporal fascia overlying the temporalis muscle in the lateral temporal region. Conversely, when a pericranial flap is potentially required, this incision should be made through the pericranium so that the pericranium will be elevated with the remainder of the coronal flap tissue. With the pericranium adherent to the overlying galeofrontalis layer, it is preserved for later use, as it can be separated from this layer within the loose areolar plane without injuring its origin or vascular supply at the peri-orbital rims. If the pericranial flap is not required, dissection continues inferiorly superficial to the pericranium, deep to the galeofrontalis, as well as over the superficial layer of the deep temporal fascia in the temporal region.

Approximately 1 cm superior to the supraorbital rims, an incision is made through the pericranium followed by subperiosteal elevator dissection to expose the supraorbital neurovascular bundles (Fig. 4-48). These may be exiting from a foramen or from a notch in the supraorbital rim. If they are in a notch, a fine elevator can be utilized through release of the bundle contents from the notch. When the neurovascular bundles are in a foramen, a small osteotome is used to fracture the small ridge of bone at the interior aspect of the foramen. Once the neurovascular bundles are released, dissection of the supraorbital rim, release of the superior orbit soft tissue, and exposure of the nasoethmoid region is possible (Fig. 4-49). However, care should be taken during the medial orbital and nasal dissection not to release the medial canthal tendon, as this may compound the effects of the medial canthal injury in a nasoethmoid fracture.

PITFALL... Once the supraorbital neurovascular bundles are released, it is tempting to extensively dissect out the medial orbital rim. However, overdissection may compromise the attachment of the medial canthal tendon, converting a simple nasoethmoid fracture into a complex one.

Laterally, the dissection continues down along the superficial layer of the deep temporal fascia (Fig. 4-50). At the horizontal level of the lateral orbital rim this fascia divides into superficial and deep layers overlying the superficial temporal fat pad. Dissection is continued inferiorly over the superficial temporal fat pad to a level immediately above the zygomatic arch (Fig. 4-51). Just above the arch the fascia is incised. Traditional descriptions involve further incision into the fat pad to protect



FIGURE 4-48 With the coronal approach, an incision above the orbital rims allows for subperiosteal dissection to expose and dissect free the supraorbital neurovascular bundles.



FIGURE 4-50 Lateral temporal dissection continues down onto the superficial layer of the deep temporal fascia.



FIGURE 4-49 After release of the supraorbital neurovascular bundles, the dissection is continued into the orbital roofs and nasal bones.

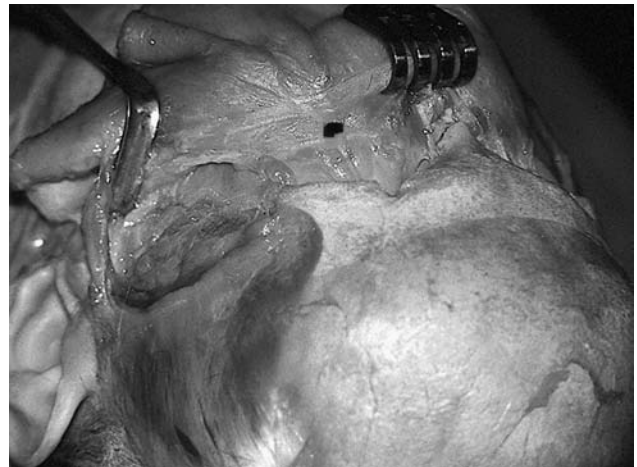


FIGURE 4-51 Just superior to the zygomatic arch, the superficial layer of the deep temporal fascia is incised, followed by dissection on the superficial temporal fat pad.

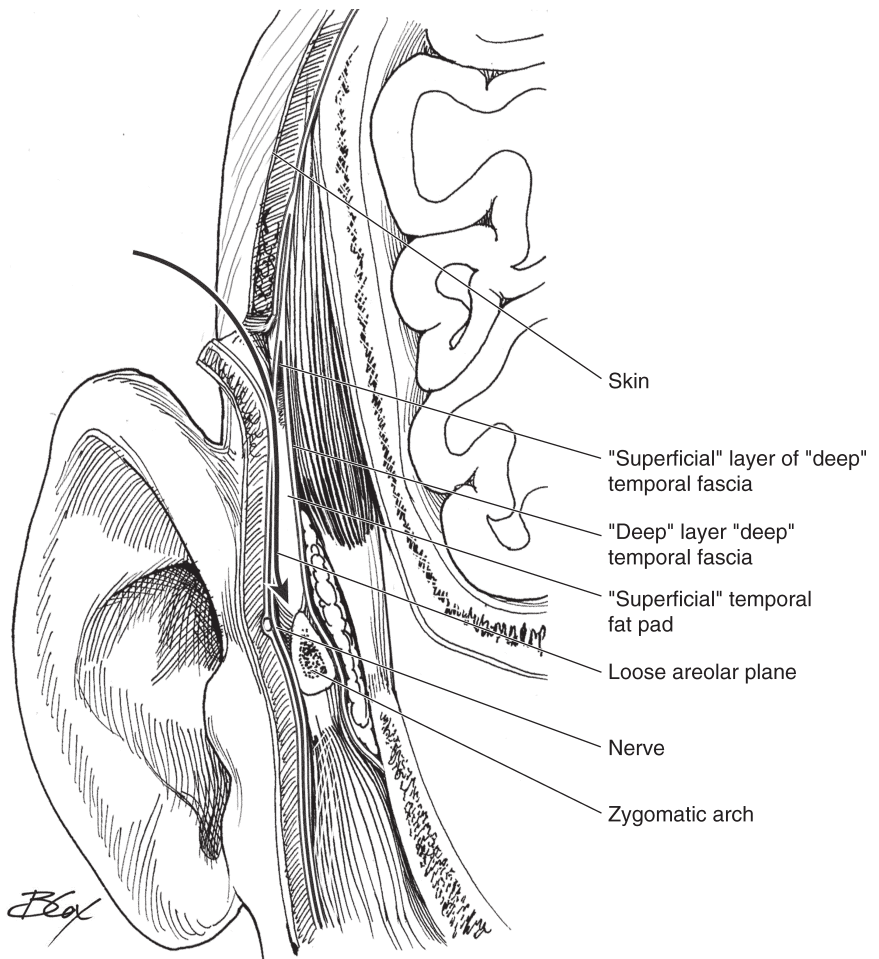


FIGURE 4-52 The pathway of dissection to the zygomatic arch.

the frontal nerve branch in the overlying temporoparietal fascia. However, deeper dissection often produces traumatic resorption of the fat pad, resulting in a posttraumatic temporal depression. Accordingly, remaining immediately deep to the superficial layer of the deep temporal fascia and minimizing significant dissection into the superficial temporal fat pad may prevent this deformity. The zygomatic arch is entered sharply from above followed by exposure of the arch from lateral to medial. The lateral orbital rim and lateral superior aspect of the zygoma is exposed by subperiosteal dissection of these regions and sharp dissection and release of the periosteum from these regions. Fig. 4-52 outlines the pathway of dissection in the temporal region.

At the completion of this dissection, the entire frontal region, lateral orbital rim (including access to the lateral and superior internal orbit), zygomatic arch, zygomatic body, as well as the lateral aspect of the inferior orbital rim are exposed. Additionally, the lateral wall of the orbit is fully exposed (Fig. 4-53 and 4-54). As previously described with closure of lower eyelid incisions, it is very important to resuspend the soft tissue structures of the upper and middle craniomaxillofacial skeleton. A systematic closure of the midface periosteum to the inferior orbital rim followed by the reapproximation and suspension of the dissected

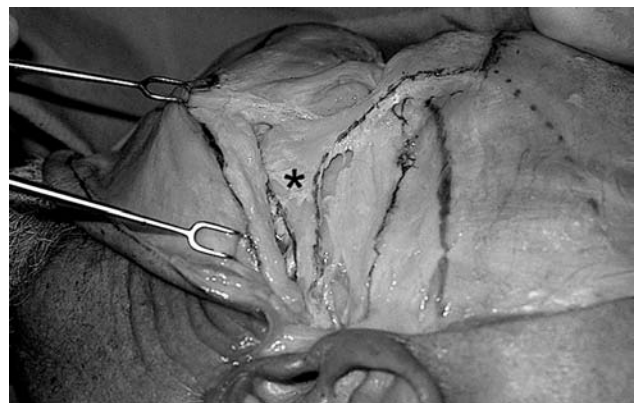


FIGURE 4-53 Completed zygomatic dissection. Note the entire zygoma is exposed (*) to the superior lateral maxillary buttress inferiorly and the lateral infraorbital rim medially.

lateral temporal tissues is very important as is lateral canthus resuspension to the lateral orbital rim.

OCCCLUSION

Prior to discussing specific treatment of facial fractures, a basic discussion of dentition and management of occlusion is essential. Adult dentition nomenclature assigns each

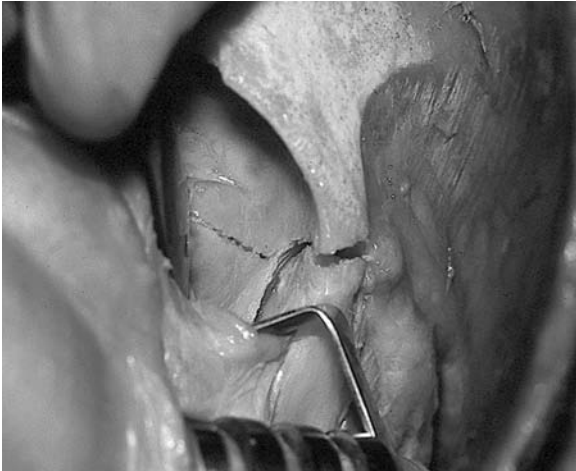


FIGURE 4-54 Via the coronal approach, the lateral orbit is clearly visible after dissection. Note the displacement of the zygoma from the sphenoid portion of the lateral orbit.

permanent tooth with a specific number, beginning with 1 for the right upper third molar and progressing along to the left upper maxillary third molar (16). This sequential numbering continues along the mandibular arch, with the left third molar being assigned 17 and right mandibular third molar being 32. The term *mesial* means toward the midline (toward the incisors), and *distal* means away from the midline or toward the molar dentition. *Buccal* means toward the lips and cheek, and *lingual* means on the inner aspect of the dentition toward the tongue.

Although it is beyond the scope of this book to describe dental injuries and applied dental anatomy, one should know that dental fractures are a common entity in maxillofacial trauma and a classification exists for documenting different types of dental fractures. For example, a class I fracture involves the enamel of the tooth only, a class II fracture includes enamel and dentin, and a class III fracture involves the pulp chamber. A class III fracture requires immediate treatment by a dentist to preserve the tooth. The tooth is anchored by the periodontal membrane (ligament) and cementum, the gingiva surrounding the tooth, and the alveolar process of the maxilla or mandible. When a tooth is loosened, it is important that living periodontal fibers be present when the avulsed tooth is considered for replantation. The literature states that replantation can take place as late as 24 hours after an avulsion. Ideally an endodontist should manage this problem by removal of the pulp and definitive filling of the root canal in the pulp chamber prior to replantation with fixation to the surrounding teeth. It usually takes about 3 weeks for a replanted tooth to take hold.

Regarding occlusion, it is very important for the surgeon to have a basic understanding of the angle classification for dental occlusion as well as to understand the concepts of centric occlusion versus various forms

of crossbite, overbite, and overjet. In a normal class I occlusion, the mesial buccal cusp of the maxillary first molar overlies the intercusp groove of the mandibular first molar. In a class II occlusion (distocclusion), this maxillary first molar mesial buccal cusp lies in the intercusp groove between the mandibular first molar and the second premolar. Finally, in a class III occlusion, the mesial buccal cusp of the maxillary first molar lies between the first and second mandibular molars. Corresponding retrognathic and prognathic profiles are usually seen with the class II and class III occlusions, respectively.

In facial trauma those patients who present with class II and class III malocclusions should be returned to the preinjury occlusion with fracture reduction and fixation. Accordingly, it is extremely important to obtain the history of the premorbid occlusion status. At the time of restoring the occlusion intraoperatively, the alignment of “wear facets” is critical to reestablishment of a premorbid occlusion (Fig. 4-55).

PEARL... Wear facets facilitate proper alignment of the mandibular and maxillary occlusion.

Most cases involving maxillary and mandibular fractures begin with establishing occlusion by the placement of arch bars. In the United States, Erich arch bars are most commonly utilized. The arch bars are initially fixated to the first premolar using 25- or 26-gauge stainless steel wire (Fig. 4-56). There are a variety of techniques for fixing these wires between the tooth and arch bar. The wires are placed between the two so that they encompass the arch bar in the tooth, and they should be twisted in a clockwise fashion to secure the wire and arch bar as high as possible on the crown on the tooth. The wires are pulled while twisting in the same clockwise direction. Following attachment of the wire and arch bar to the premolar tooth, sequential wire fixation is applied to all teeth as far distally as possible. Once again, depending on the fracture situation the patient may or may not be placed in maxillomandibular fixation (MMF) at

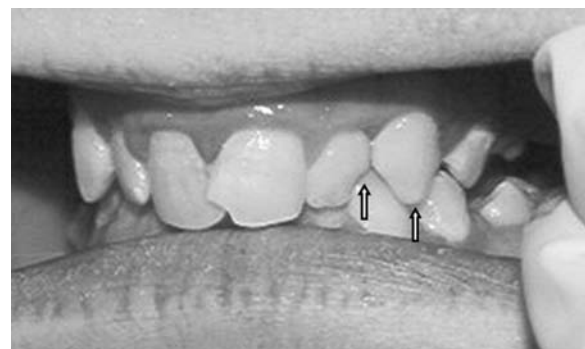


FIGURE 4-55 Restoring preinjury occlusion is facilitated by the guidance of “wear facets” (arrows) on the teeth.



FIGURE 4-56 Placement of stainless steel arch bars to allow for maxillomandibular fixation. An acrylic splint (arrow) has been used in this case to guide the occlusion during placement into maxillomandibular fixation.

the beginning of the procedure. In complicated panfacial fractures, the MMF may not be applied until later in the procedure. However, in more isolated mandibular and maxillary fractures the MMF is applied prior to fixation of the fractures. As mentioned previously, it is important to establish the normal, premorbid, and preinjury occlusion. Using wear facets to guide teeth into position is of critical importance.

PEARL... An Erich arch bar not only assists in reestablishing normal occlusion, it also acts as a tension band when placing plates at the inferior border of the mandible.

The alternative to use of arch bars is the use of all the Ivy loops for dental fixation. A loop of wire is placed around two teeth and secured. Another alternative is to place screws into the mandible and maxilla followed by placing loops of wire between them to create MMF.

CONTROVERSY

Whether Ivy loops or screw fixation provides an adequate form of MMF is controversial. In displaced or comminuted fractures, arch bars are still generally recommended.

It may be difficult, even with the arch bar, to restore a normal dental arch in some patients who sustain sagittal fractures to the maxilla. In this situation obtaining dental impressions to fabricate a dental splint can be extremely useful. A dental impression is obtained from the patient, and "surgery" is performed on the casts to restore what is assumed to be a normal premorbid dental arch. This is lined up with the opposing dental arch, followed by creation of an acrylic splint. This splint can be placed to

guide the dental arch into occlusion at the time of surgery (Fig. 4-56).

Finally, in patients with dentures, the dentures can be wired or screwed into the appropriate dental arch and used as an occlusion-guiding device. They will require repair preoperatively if they are fractured.

MANDIBULAR FRACTURES

Mandibular fractures account for a significant percentage of all facial fractures. Historically, the treatment of such fractures represents the basis for evolution of internal fixation techniques in the remainder of the facial skeleton. Accordingly, mandibular fractures command a significant amount of attention.

This section reviews briefly the functional anatomy, a classification of mandibular fractures, and treatment options for each anatomic region of the mandible.

Functional Anatomy and Classification

Mandibular fractures can be classified in many different ways, but perhaps the most understandable way is to describe them by anatomic region. Fig. 4-57 shows these anatomic regions, which include the dental alveolus, the symphysis/parasymphysis, the body, the angle, the ramus, the coronoid, and condyle regions. When describing fractures of one of these specific regions one would also describe whether the fracture is simple or comminuted, and whether it is nondisplaced, minimally displaced, moderately displaced, or severely displaced. In the pediatric patient, one would also state whether a simple fracture is a completed fracture or a greenstick type of fracture.

Stability concepts are present throughout the literature, and a basic understanding is essential for both the

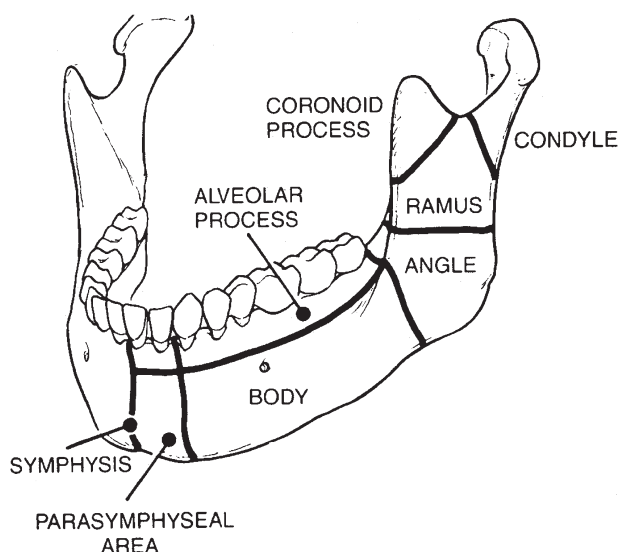


FIGURE 4-57 Anatomic regions of the mandible. (From Sinn DP, Hill SC, Watson SW. Mandibular fractures. In: Sherman JE, ed. Surgery with Facial Bone Fractures. New York: Churchill Livingstone, 1987:172, with permission.)

evaluation and treatment of mandible fractures. Basically, the muscles of the mastication (suprahyoid musculature in the anterior mandible, with the masseter, temporalis, and the medial and lateral pterygoid muscles in the angle region) influence the distraction of fractures depending on the anatomic region. The fractures can traditionally be considered favorable or unfavorable depending on the region and orientation of the fracture. Theoretically, a favorable fracture should require less internal fixation than an unfavorable fracture. Mandible biomechanics is generally discussed in terms of forces being placed on the mandible such that the load placed on the anterior dentition (such as in biting an apple) would place a corresponding compressive force along the inferior margin of the mandible (Fig. 4-58). In this scenario, the inferior border is considered under “compression,” whereas the superior border at the dental alveolus would be separated. Accordingly, to maintain alignment at the superior border, a fixation device such as an arch bar or plate would be required to be placed under tension along this border. Therefore, one can think of the mandible in terms of having tension and compression surfaces according to the load that is placed. Traditionally, the entire mandibular dental arch is considered to be under tension, whereas the inferior mandibular border can be under compression. A study by Rudderman and Mullen¹ disputes this theoretical description of forces, stating that the bite loads placed at different portions of the mandibular arch change the biomechanics in a very dynamic way. For example, with certain bite loads the compression and tension fluctuate and at times are neutral, whereas other loads switch between tension and compression. However, we continue to consider the superior border of the mandible to be the “tension” zone and the inferior border of the mandible to be the “compression” zone. Fortunately, experience has taught us that treating fractures in this fashion would generally provide an environment that allows for adequate bone healing.

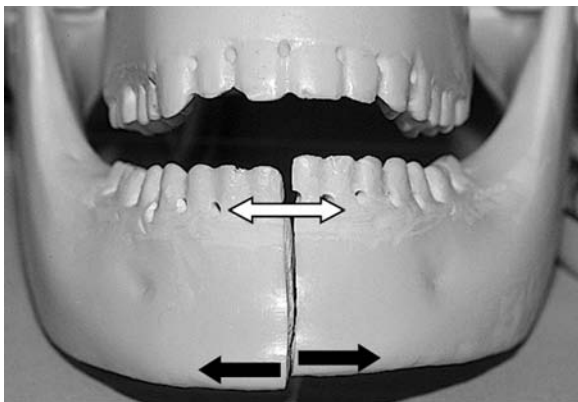


FIGURE 4-58 Basic mandibular biomechanics, demonstrating distraction at the superior border (white arrow) and compression at the inferior border (black arrows) of the mandible.

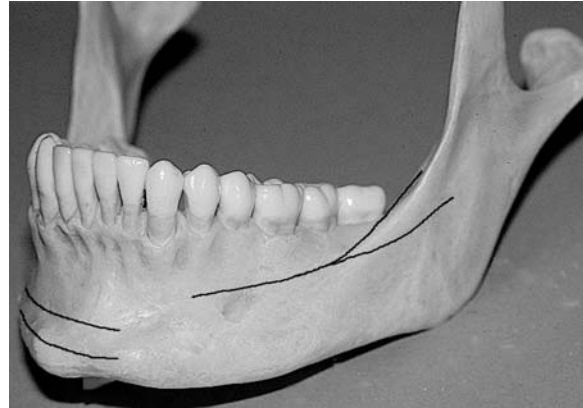


FIGURE 4-59 Champy's ideal lines of osteosynthesis.

Champy worked out experimentally these areas of tension and compression and defined the “ideal lines of osteosynthesis” (Fig. 4-59). Basically, it is believed that if a tension band is placed along these lines, bone healing should occur. In the angle and the majority of the body region, these lines are along the superior border, whereas in the symphyseal region they are along the inferior border.

The most common type of tension band used is an arch bar, which bridges the fracture at the alveolus. If placed properly, the arch bar (and interdental wire fixation) should provide adequate strength as a tension band to prevent separation at the superior border (Fig. 4-60).

Although statistics vary, there is generally some agreement as to what are the most common mandibular fractures. The most common fractures occur in the symphyseal/parasymphyseal regions, followed by subcondylar and body fractures, whereas ascending ramus and coronoid fractures are the least common.

Symphysis and Parasymphyseal Fractures

Although symphyseal and parasymphyseal fractures are often separated into two categories, we combine them in this section. From an anatomic perspective the key

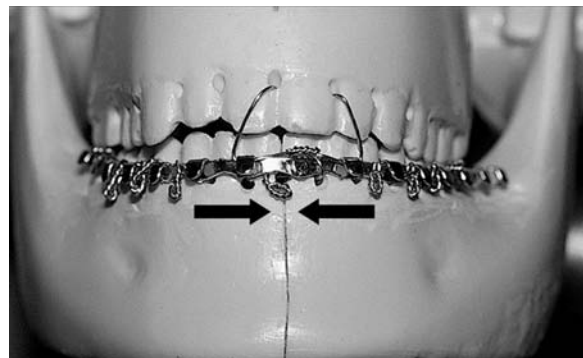


FIGURE 4-60 An arch bar commonly serves as a “tension band” to maintain reduction and prevent distraction of the alveolar border (arrows).

difference is that parasymphiseal fractures, by definition involving the canine tooth area, tend to be located in the region of the inferior alveolar and mental nerve, which need to be considered in terms of both exposure and fixation placement. Fractures in this region represent the only area in the mandible that can almost always be approached through an intraoral approach. Several different options are reviewed.

As with many regions of the mandible, the use of MMF alone, if applied correctly, may be sufficient for treatment of this fracture. The MMF should remain in place for 6 weeks, and the wires must be tightened frequently. The problem with MMF is that, despite providing alignment and stabilization at the superior alveolar border, it does not overcome any torsional affects at the inferior border. Accordingly, stabilization at the inferior border is often recommended as well. This is particularly the case when fractures of the anterior mandible are combined with either angle or subcondylar mandible fractures. In this scenario, there tends to be increased separation and displacement of the inferior border. It is in this situation that a fixation device may be indicated.

When performing internal fixation of symphyseal fractures, it is wise to “preload” the fracture with some sort of device, which not only reduces the fracture but also places compression on the fracture site. Although cumbersome reduction forceps had been described in the past, the most common technique currently is the use of either a towel clamp or a specially designed modified towel clamp to provide reduction in this area (Fig. 4–61).

A classic technique for providing reduction and fixation in the anterior mandible is the compression plate, which is applied to the inferior border of the mandible after preloading, as previously described. Screws are then sequentially placed in a bicortical fashion in the plate hole closest to the fracture line. This provides compression

across this fracture line, as has been described previously. The remaining holes are drilled in a neutral position without compression and the screws are placed.

Fig. 4–62 shows a compression plate with a superiorly positioned tension band plate. This plate is probably redundant, as an arch bar could also be serving as a tension band. Also of note is that plates placed more superiorly in the mandible put the dental roots at risk.

A compression plate is a midsize plate with larger screws than would be used with miniplates. In most plating systems, there is a mandibular plate with an oblong hole that allows for placement of bicortical screws, most of which are 2.3 or 2.4 mm in thread width. Screws can be placed either “eccentrically” or “neutrally.” When placed eccentrically, the screw is placed in a bicortical drill hole *away* from the fracture. When the screw is tightened, the bone is forced toward the fracture line and compression is produced. Conversely, when the screw is placed in the center of the plate hole, or “neutrally,” no compression is produced. Key to the placement of compression plates is the concept of “overbending.” As mentioned previously, the lingual cortex tends to splay apart during fixation of the outer or buccal cortex. Accordingly, the plate should be overbent immediately over the fracture line (so that there is about 2 to 3 mm of space between the plate and reduced fracture line). When the bicortical screws are placed, there will be apposition of the buccal cortex.

Another technique that allows for compression in the anterior symphysis is lag screw fixation. This technique has become quite popular because of the stabilization it provides. As a rule, two screws are placed across the symphyseal fracture to prevent torsion (Fig. 4–63). After preloading of the fracture site, the procedure is begun by drilling a gliding hole (of a size that is the same as or larger than the screw thread width) in the proximal cortex, followed by drilling an appropriate-size smaller



FIGURE 4–61 A modified towel clamp is use to assist in maintaining reduction and “preload” the parasymphiseal fracture site.

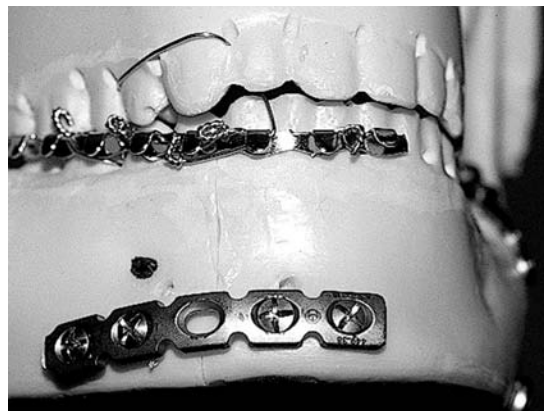


FIGURE 4–62 A midsize plate has been applied along the inferior border of the mandible in compression. Either a smaller plate or an arch bar can be used as a tension band. If a plate is used, the screws should be monocortical and are placed between the tooth roots.

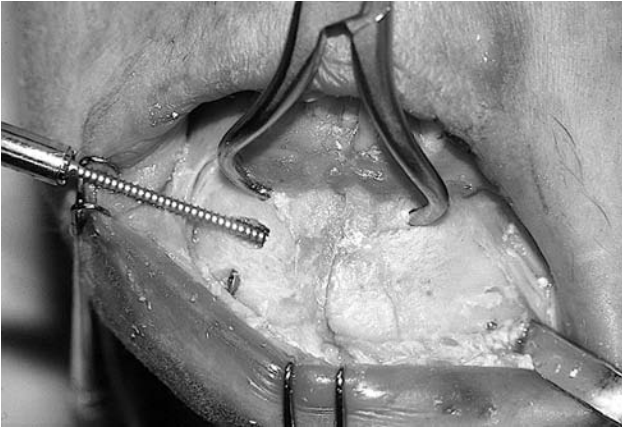


FIGURE 4-63 The use of the lag screw technique for parasymphyseal fractures. After preloading with reduction forceps, the lag screw technique is used, ensuring that the two screws are placed inferior to the mental foramen.

hole in the distal cortex. The appropriate-size screw (generally 2.3-mm thread or larger) is placed. As the screw is tightened through the countersunk proximal bone and as the thread engages the distal bone, compression occurs across the fracture line. A second screw is placed identically either below or above the first screw. It is important that the two screws are placed low enough in the mandible so as not to traverse the mental nerve or injure the incisor tooth roots. The hole should be drilled a significant distance away from the fracture line to provide the proper compression through both the buccal and lingual cortex. A screw measuring between 34 and 40 mm in length is commonly required.

PITFALL... Compression plates and lag screw fixation have the theoretic advantage of promoting primary bone healing. However, as rigid fixation is produced, any malalignment or malocclusion that is created cannot be adjusted postoperatively, as with semirigid fixation.

Many surgeons prefer to use semirigid fixation in symphyseal/parasymphyseal fractures. When these fractures are noncomminuted and are either nondisplaced or easily reduced, miniplates may be utilized along the lower margin of the mandible. In general, two 2.0-mm plates should be applied inferior to the dental roots, avoiding the mental foramen (Fig. 4-64). An alternative method is to use a four-hole, three-dimensional plate in this region.

It should be noted that when using such miniplates, which are generally 2.0 mm in screw size, the screws are placed in a monocortical fashion. Once again, preloading forceps can be applied prior to placement of these small plates. Occasionally bilateral symphyseal fractures will be present.

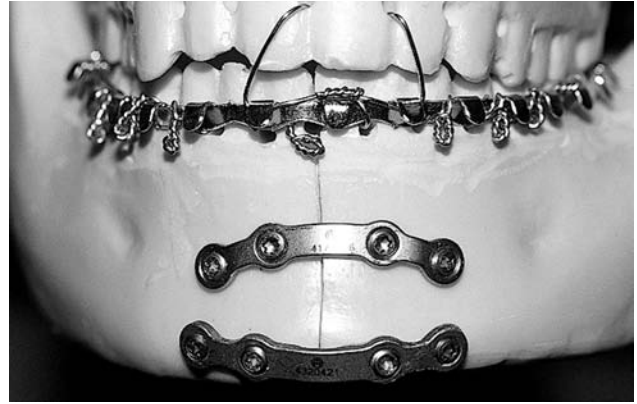


FIGURE 4-64 An example of the use of two miniplates for a symphyseal fracture. An alternative would be a box-shaped miniplate in this region. Once again, the principle of over bending should be taken into account even though the screws placed are monocortical.

CONTROVERSY

Although MMF is released immediately by some surgeons using semirigid fixation, most believe that 1 to 2 weeks of MMF provide for corrections of any alignment or occlusal errors.

When comminution of bone is present, a larger reconstruction-type plate should be used (Fig. 4-65). As stated earlier, such a plate can bear the load across the comminuted area, allowing for secondary bone healing. An alternative in such a comminuted fracture is the use of an external fixation device. Although this is still considered to be a treatment of choice in infected wounds in some centers, it has been clearly demonstrated that



FIGURE 4-65 A comminuted symphyseal fracture reduced with a miniplate superiorly, lag screw fixation to reposition the comminuted segment, and a bridging reconstruction plate.

reconstruction plate fixation is equally or more effective in such fractures.

Although pediatric fractures are beyond the scope of this book, one should be aware that plating in this and other regions of the infantile or pediatric mandible can be dangerous because of the presence of secondary tooth roots. However, for panfacial fractures in which stabilization of the mandible is important to allow for appropriate reduction and fixation of the midface and upper maxillofacial skeleton, internal fixation may be necessary. It is of critical importance that radiographs are obtained that show where these secondary teeth are, so that the plate can be placed inferior to them. As a rule, if plates are placed in a pediatric mandible, they should be placed as inferior as possible along the mandibular border, and generally the screws should be monocortical. Alternatives for treatment of pediatric fractures include the use of circummandibular wires, which can be placed either to the arch bars if the primary dentition is strong enough, or preferably to a prefabricated splint. Additionally, the use of resorbable plates have a role in this patient population.

CONTROVERSY

Conservative treatment of pediatric mandibular fractures is the rule. However, small screws and plates may be necessary in some patients.

In patients in whom the dentition is marginal or absent, the critical factor in determining what type of fixation is adequate is the mandibular height. This applies essentially to all regions of the mandible. In patients with less than 2 cm of mandibular height, a rigid form of fixation should be considered. When the mandibular height is less than 1 cm, a reconstruction plate should be used, whereas placement of cancellous bone grafts are considered, as necessary. Additional stability potentially can be obtained by either splint fabrication or using the patient's dentures, the latter being secured by either circummandibular wires or screw fixation.

BODY FRACTURES

The principal difference between body and symphyseal fractures is related to the difficulty of exposure. Although intraoral repair of more anterior body fractures is still quite possible, the use of transcutaneous trocar drilling and screw placement becomes necessary as the fractures move more posteriorly toward the angle (Fig. 4–41). Unless the surgeon has significant successful experience in such trocar-requiring techniques, one should probably use an external submandibular approach for posterior fractures and in those that are comminuted. Once again, the use of MMF alone is a viable option, although torsional affects may lead to malunion or a nonunion.

Regarding fracture repair, traditional approaches include MMF alone, or simple wire interosseous fixation with MMF may be an option with the wire being placed along the inferior border. As with the symphyseal region, body fractures have classically been repaired with dynamic compression plates. Intraoral placement is exceedingly difficult, but the DCP technique is facilitated by transcutaneous approaches.

As with other regions of the mandible, miniplates have gained popularity in body fractures. In general, two plates or a square-shaped plate are used. It is important to fully understand the course of the inferior alveolar nerve as it approaches the mental foramen. Studies have shown that, on average, the nerve traverses the bone ~6 mm below the level of the foramen prior to proceeding upward to exit as the mental nerve. Accordingly, preoperative x-rays should be closely scrutinized for the exact location of this nerve. Miniplates can be placed immediately below the nerve, immediately above the nerve (with short screws to avoid tooth roots), or a combination of both.

Although lag screw fixation is occasionally possible in more anterior body fractures, it is generally quite difficult unless there is an oblique sagittal fracture. In this situation, lag screw fixation is made possible by the obliquity of the fracture. Once again, transcutaneous trocar screw placement is generally required.

As with the symphyseal region, comminuted fractures of the body should be spanned with a load-bearing reconstruction plate. At least three to four bicortical screws should be placed in solid bone both proximal and distal to the comminuted segment. Although sometimes the comminution is limited to one or two larger fragments and the tendency exists to place smaller plates across these large segments, a perhaps more predictable way of fixating these fractures is to use small plates or wires to reduce the fracture and then span the fracture fragments with the reconstruction plate. In large avulsion wounds such as a gunshot blast to the mandible, it is often the case that both the symphysis and body are involved. In this case, after minimal debridement of bone fragments and soft tissue, this defect is spanned anatomically with a large, strong reconstruction plate. The locking-screw type of reconstruction plate is ideal for this situation. As with symphyseal fractures, the same criteria exist for fractures of the atrophic mandible in the body region, and reconstruction plates should be used whether the fractures are comminuted or not.

ANGLE FRACTURES

Along with symphyseal and parasymphyseal fractures, the angle of the mandible is a very common location for fractures. This fracture is commonly associated with a fracture on the contralateral parasymphyseal or body region and, accordingly this should be looked for.

PEARL... Angle fractures are commonly associated with contralateral parasymphyseal or body fractures.

There is perhaps no more controversial region in the mandible than the angle; controversy exists about what is considered adequate fixation and about how to treat the fracture. Studies are conflicting about these issues, but more recent prospective studies point to a more conservative approach for the treatment of mandible fractures.

The angle represents a region where MMF is a very good option as a treatment modality for this sort of fracture, particularly when it is an isolated noncomminuted fracture. Of note is that when this fracture is in the line of a mandibular second or third molar, this tooth should be carefully examined. Infections in this region can occur, just like any other region of the mandibular dental arch, when a line fracture is through a tooth that is loose, fractured, or decayed. In this latter situation, tooth removal should be performed prior to any form of definitive treatment of the fracture. Conversely, when a tooth is in the line of fracture but is still solidly in place, there remains some controversy as to whether or not the tooth needs to be removed. The problem with removing the tooth is that it acts as a buttress to the alveolar ridge in the angle region, and, when removed, a significant defect of the bone can be created. Accordingly, we generally choose to leave the tooth in place whenever possible.

Current standards dictate that open reduction and fixation of simple, noncomminuted angle fractures be performed in a manner that limits morbidity. Accordingly, intraoral approaches to this region are preferred. Extraoral approaches are reserved for more difficult fractures, such as when fracture orientation makes intraoral reduction difficult, and for comminuted angle fractures and fractures in combination with other fractures sites (for example a subcondylar fracture in combination with an angle fracture). These types of fractures are approached through a submandibular skin incision as described previously. The advantage of this approach is that it provides excellent exposure to the posterior body, angle, and ramus region. Such exposure is optimal for the less experienced surgeon, particularly if a fixation technique is utilized that involves placing a plate at the inferior border of a mandible fracture. Because of the axial visualization, fracture reduction is optimized. However, for placement of one or two plates along the superior border on or near the external oblique ridge, an intraoral incision is ideal, and rarely is a transbuccal trocar needed.

The literature supports the use of a single plate along the superior border of the angle fracture. Fig. 4-66 demonstrates the use of one plate placed on each side of the external oblique ridge. It is not yet determined whether



FIGURE 4-66 A miniplate placed on either side of the external oblique ridge in this angle fracture.

two plates are superior to one plate, but it certainly does not seem to be detrimental in any way to use two plates. If only one plate is used, it could be placed on either side of the external oblique ridge or, in some cases, directly on this ridge. When the plate is placed on the outer surface of the oblique ridge, a trocar is sometimes necessary for transcutaneous placement of screws, as the placement of the screws intraorally can be quite difficult.

PEARL... Miniplates provide adequate fixation of isolated, noncomminuted angle fractures.

Miniplates have also been described as being used both at the oblique ridge region and along the lower margin of the mandible. The advantage to this approach is that there is a greater likelihood of proper alignment of the fracture at the interior border. The disadvantage, whether through intraoral or extraoral approaches, is that there is significant stripping of periosteum from this region. It has been speculated that this devascularization of the region by stripping of the periosteum may lead to increased complications for angle fractures. However, this has not been proven.

Larger plates have been classically described for standard use in the angle region. The tradition, as noted in AO/ASIF teaching, is to place the compression plate or larger plate in a noncompressive mode along the inferior border, immediately below the inferior alveolar nerve canal. This is generally done in combination with a tension



FIGURE 4-67 A right comminuted angle fracture is repaired via a submandibular external approach using a reconstruction plate to bridge the comminuted segments and bear the functional load in this region of the posterior mandible.

band plate along the superior border. This superior border plate is identical to the single plate as has been previously described. This approach is falling into disfavor for several reasons. First, it is a difficult technique to apply intraorally, as the use of a transbuccal trocar is required. Reduction problems are common with an intraoral inferior border. Accordingly, an external approach is often required. Devascularization problems along with the external scar have contributed to the increased popularity of intraoral placement of a single or double miniplate at the superior border.

Reconstruction plates are necessary when there is comminution of any significant degree at the angle region, particularly in combination with other mandibular fractures. This necessitates an external approach to allow for the placement of a longer plate with three to four screws on each side of the comminution in order that the plate can bear the functional load for the angle region (Fig. 4-67).

Finally, lag screw fixation has been described in the angle fractures, although it is not commonly accepted as a predictable technique because of the technical difficulty. Niederdelmann describes placing a single long lag screw beginning in the body of the mandible above the inferior alveolar nerve and extending into the region of the ramus in an oblique fashion. This is technically difficult, and one should be highly experienced in the treatment of angle fractures with more traditional approaches prior to trying this technique. However, the lag screw fixation technique can be very useful for oblique fractures of the angle region. This approach can be performed through a transoral approach using a trocar; the key to this technique is that at least three screws are utilized and that the inferior alveolar nerve is avoided.

RAMUS FRACTURES

Although isolated ramus fractures are quite unusual and are often confused with low subcondylar fractures, they

can be a difficult problem. An arch bar cannot be used as a tension band in this region, but MMF is still utilized to maintain the proper relationship. If the fracture is isolated, MMF alone may be adequate treatment for 6 weeks. Other approaches include placement of a plate lateral to the external oblique ridge through the intraoral approach, just as is done in angle fractures. In the scenario of comminution, or when the fracture is combined with other significant mandibular fractures, the extraoral approach may be required to plate the posterior aspect of the ascending ramus.

SUBCONDYLAR FRACTURES

Subcondylar fractures are relatively common. An isolated unilateral subcondylar fracture is generally treated conservatively with MMF for 2 weeks in children and 2 to 3 weeks in adults. The indications for open reduction of a subcondylar fracture remain quite controversial. However, it is perhaps appropriate to open and reduce a subcondylar fracture in the following situations: (1) the displaced condyle interferes with function; (2) the condylar dislocation interferes with the ability to obtain adequate occlusion by closed reduction; (3) there are foreign bodies in the joint capsule; (4) the restoration of the vertical height made by reduction of the subcondylar fracture is essential for reestablishment of posterior vertical facial height (e.g., there are multiple other injuries such as with a panfacial fracture); (5) there is severe lateral displacement of the condyle; and (6) MMF is contraindicated because of the medical condition of the patient. Other relative indications include bilateral severely displaced subcondylar fractures in which posterior vertical height may not be maintained through closed reduction alone. The latter is an example of a controversial area, and some surgeons feel that there is an increased chance for a vascular necrosis when the condyle and subcondylar region are exposed. It is sometimes necessary to completely dissect free this bony fragment, increasing the chances of resorption. When using closed reduction techniques, one must counsel patients that if their occlusion changes during the healing process, an open repair might be necessary. Similarly, an osteotomy may be necessary to close the anterior open bite caused by the collapse of the posterior occlusion.

If the condyle or subcondylar region is explored, one must also be aware of the potential for other pitfalls or for open exploration, such as facial nerve injuries, as discussed above (see Surgical Approaches). Some of these risks are limited by intraoral, endoscopic-assisted approaches that are not yet proven to be universally accepted. The reduction is often quite difficult because of the medial pull of the pterygoid muscles on this region. However, once the fracture is reduced it can be fixated in any number of ways including no fixation at all (in other words, just relying on the reduction). The optimal form of fixation also remains

controversial, but it is agreed that a strong, small plate should be used to bridge this gap areas.

CONTROVERSY

The debate about when subcondylar fractures should be opened will continue indefinitely, as there has been no definitive study to determine which method, open or closed, is superior.

Postoperative Management

Those patients who have been treated for mandibular fractures may have arch bars in place. Care of the traumatized gingiva involves brushing with a soft bristle toothbrush and frequently gargling with a specially formulated oral care solution. A persistent area of controversy remains how long MMF should be maintained. The answer to this is not yet known. Some surgeons feel that MMF should be removed immediately after repair, after checking for appropriate pre-morbid occlusion. Those opposed to this believe that if the mandible is fixed rigidly without postoperative MMF, there is limited opportunity for “self-correction.” Accordingly, these surgeons choose to use smaller plates that allow some mobility (i.e., are not rigid). This “semirigid” fixation may allow for a small amount of motion within the fracture sites in the presence of a fixed MMF. One area of agreement is that when there is a high subcondylar or condylar fracture, the patient should be allowed to resume functioning (the MMF is removed) in a relatively short period of time (within about 2 weeks). These principles are discussed below (see Panfacial Fractures).

MAXILLARY FRACTURES

Although not as common as mandibular fractures, maxillary fractures do occur with relative frequency. They can result from either a direct blow to the central portion of the facial skeleton or impact to the mandible such that the forces are transmitted into the maxilla, with fractures then occurring at weak points of this structure.

When considering the anatomy of the midface, the most important aspect is the buttresses (Fig. 4–68). The vertical buttresses (lateral or zygomaticomaxillary, and medial or nasomaxillary) are generally described as the most important structural pillars of the midface. The horizontal buttresses impact the width of the face and stabilize the maxilla in a transverse dimension. The latter buttresses include the maxillary alveolus, which stabilizes the dental arch and palate, whereas the superior horizontal buttresses include the one that proceeds from the zygomatic arch across the inferior orbital rim and nasal root to the contralateral orbital rim and zygomatic arch. Another superior horizontal buttress is the frontal bar,

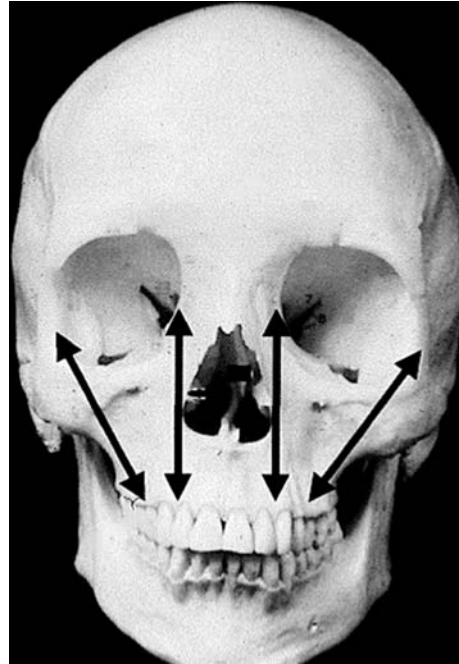


FIGURE 4–68 The vertical buttresses of the midface, including the lateral (zygomaticomaxillary) and medial (nasomaxillary) buttresses.

including the supraorbital rims and glabella. The proper position of these buttresses, both vertical and horizontal, is the key to maintaining the height, width, and projection of the midface, which becomes even more important in terms of panfacial fractures.

Fractures of the maxilla and midface are traditionally described by the Le Fort classification (Fig. 4–69). A Le Fort I is considered a fracture that crosses low on the lateral buttress, through the lower portion of pyriform aperture, across the base of the nasal septum and then through the same structures on the opposite side. The Le Fort II also fractures through the lateral buttress, proceeding through the infraorbital rim and nasal root. Finally, the Le Fort III fracture, or craniofacial disjunction, fractures through the zygomatic arch and lateral orbital rim, proceeding across the floor of the orbit through the nasal bridge, then through the corresponding structures on the opposite side. This system of describing fractures is good, but experience tells us that describing the fractures in greater detail provides more information. For example, a panfacial fracture is often described as a Le Fort III, but rarely is it a pure Le Fort III as traditionally described. Rather, it may involve a zygomatic fracture and Le Fort I or II level fractures on the ipsilateral side with either a Le Fort I or II fracture on the opposite side. The latter description is much more informative and, other than when the isolated Le Fort I or Le Fort II level fractures occasionally occur, further descriptive terms should be utilized. Also associated with these panfacial fractures can

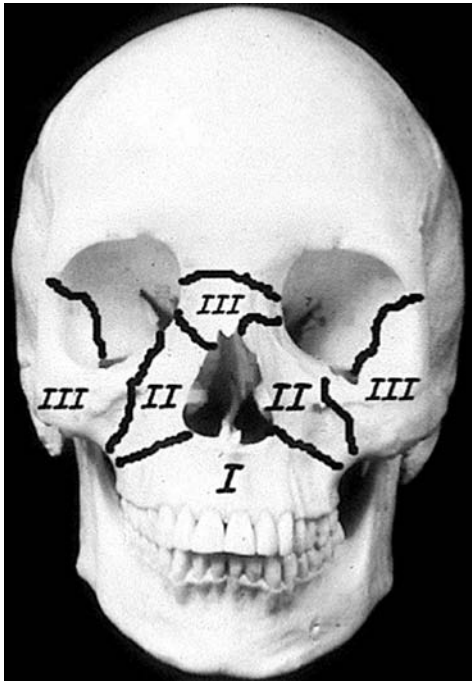


FIGURE 4-69 A diagram depicting the classic Le Fort classification of types I, II, and III.

be fractures through the hard palate as well as through the dental alveolus, and these should be described. This section discusses the repair of pure maxillary fractures (Le Fort I and II); more superior fractures (Le Fort III) are discussed below (see Panfacial Fractures).

CONTROVERSY

Le Fort terminology can be misleading and non-descriptive, particularly when fractures exist at the “Le Fort III” level.

Most fractures involving an isolated segment of the maxillary dental alveolus can be treated by placing the segment into the arch bar and fixating it to the surrounding teeth. The problem with this technique is that it may allow some prolapse of the segment, leading eventually to malocclusion, even when placed in MMF. Two alternatives include construction of a splint to restore the proper curvature of the dental arch. Alternatively, the segments are sometimes of adequate height that bone is present in the segment above the dental roots. In this situation, the segments can be plated into position. However, extreme care must be taken to avoid injury to the tooth roots. Some alveolar segmental fractures also split the palate in the sagittal dimension. These posterior aspects of these fractures are difficult to reduce and may benefit from open reduction and fixation of the palate (Fig. 4-70). This becomes even more

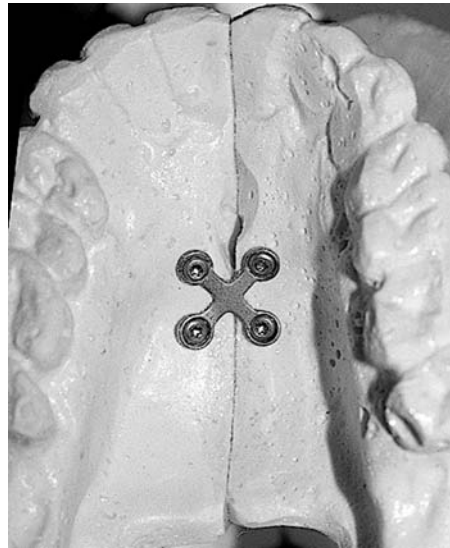


FIGURE 4-70 The use of an X plate for a palatal split fracture.

important when the palatal fracture is more centrally located and combined with a unilateral Le Fort I or II fracture. Such fractures are exceedingly unstable and should be treated either with open reduction and plating of the palate or through the construction of a full palatal splint. If these fractures are not reduced and fixated properly, the dental arch widens and possibly rotates, leading to a malocclusion. This is particularly important with a panfacial fracture. If the patient is edentulous and has an intact denture, the denture can be screwed into the alveolus and act as an excellent splint to maintain proper curvature of the maxillary alveolus.

As with all fractures, proper reduction is of critical importance to the eventual restoration of normal height and width of the midface. As stated earlier in this chapter, rocking the maxilla is an important aspect of the physical exam. The key to this maneuver is to determine both whether the maxilla is mobile as well as whether there is pain or tenderness in the infraorbital rim and nasal region. If the latter is present without mobility of the maxilla, it may imply solid impaction suggestive of upward rotation of the interior maxilla. With such impaction, Rowe or Ashe forceps can be very useful for disimpacting the maxilla. Once the maxilla is loosened, it can be placed in the appropriate position. Suspension wires from the infraorbital rim and zygomatic arch have been described in older studies, but the lack of control in wire tightening and possibly shifting of the maxillary segment make these techniques obsolete. Accordingly, the key is fixation of the medial and lateral buttresses with appropriately strong plates to bear the functional load. The latter remains somewhat controversial, but plates designed for screws of 1.5- to 2.0-mm thread width are usually of adequate strength to withstand functional loads in this region. After exposing the Le Fort

I level fractures with either a unilateral or bilateral buccal sulcus incisions (or through a transvestibular incision in combination fractures), the bone alignment is obtained in the Le Fort level and plates placed (Figs. 4-71 and 4-72). Once again, it is important to obtain precise alignment so that the occlusion is not altered from its pre-morbid condition.

When precise repositioning of the buttresses is obtained with creation of the proper vertical maxillary height, bone gaps may result. Generally, these bone gaps are from dislocated pieces of bone that can be located and repositioned to guide maxillary vertical height. However, occasionally the defect may be significant enough that bone grafts are required (Fig. 4-73). Some surgeons believe that the plates themselves are of adequate strength to maintain a load over time. However, repetitive forces placed on the buttresses may break, bend, or displace these plates, leading to a

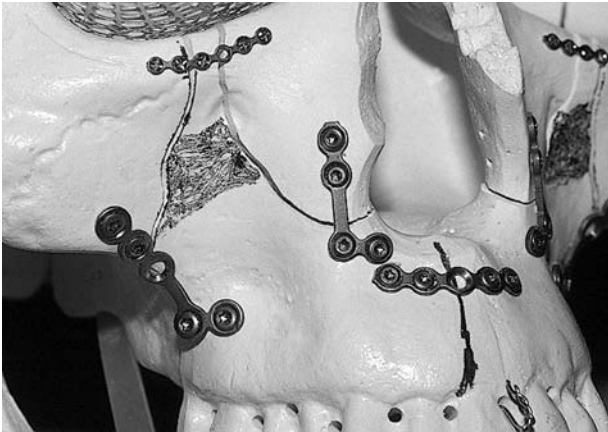


FIGURE 4-71 A Le Fort II level fracture with a split palate, after reduction and repair of lateral and medial buttresses as well as the vertical premaxillary fracture with the appropriate size plate fixation.

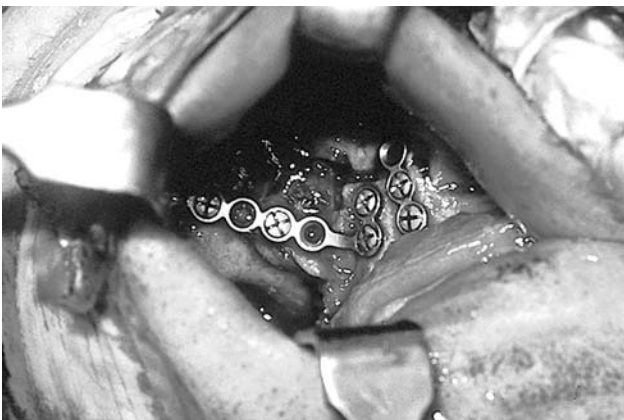


FIGURE 4-72 Intraoperative photograph of a Le Fort I level fracture after exposure through the upper buccal sulcus incision. An "L"-shaped plate is placed along the lateral buttress and a straight five-hole plate placed along the medial buttress.



FIGURE 4-73 This Le Fort I level fracture is an example of where there is absence of bone along the left lateral buttress (arrows).

malocclusion. Accordingly, it is probably wise to bone graft any buttress defect. Calvarial bone grafts offer the ideal bone for this purpose, but occasionally a section of the maxillary sinus wall bone of adequate thickness and strength may be located. The bone graft is placed in one of several ways. One method involves loosening the plate, allowing for the bone graft to be wedged beneath the plate. The plate is then retightened (Fig. 4-74). Conversely, a bone graft can be placed in the buttress region defect and fixated with a plate or lag screw fixation. Either way the goal is to reestablish bony continuity so that there will be eventual solid bony union while at the same time preserving the proper vertical heights in the anterior maxilla.

PEARL... Use bone grafts to reconstruct any buttress defect to prevent late malunion and malocclusion.

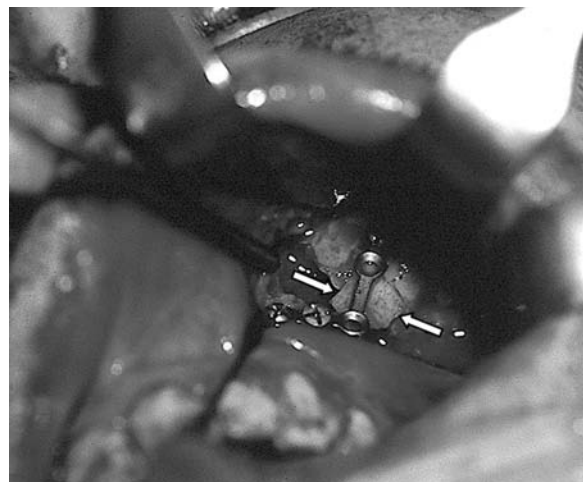


FIGURE 4-74 An interposition calvarial bone graft (arrows) is placed and secured deep to the L-shaped buttress plate.

Pure, classically described Le Fort II fractures are somewhat unusual, as they often occur in combination with nasal fractures and Le Fort level I fractures. Additionally, rather than proceeding across the root of the bony nose, Le Fort II fractures may proceed from the medial orbital floor into a superior aspect of the pyriform aperture. The key with these fractures remains stabilization of the lateral buttresses as was described with Le Fort I fractures. Unless there is a severe nasoethmoid fracture associated with this injury, it is probably not necessary to perform open fixation of the fractures at the root of the nose. Rigid fixation of both the lateral and medial buttresses when Le Fort I level fractures exist, along with smaller plate fixation along the infraorbital rim component of the fracture, provides an appropriate repair. As mentioned, closed reduction of the nasal root fracture is probably adequate. A common yet rarely described fracture is one that may be isolated, in combination with a zygomatic fracture, or sometimes in combination with a unilateral Le Fort II. A Le Fort I level fracture is what can be called a “nasomaxillary” fracture. This fracture involves the medial orbital wall and nasal bones along with a portion of the superior aspect of the pyriform aperture. Improper reduction of this segment can lead to poor reduction of the Le Fort one level, leading to a malocclusion, or to malposition of the zygoma and orbital floor. It is extremely important for this fracture to be properly realigned and, when necessary, fixated.

As classic Le Fort III fractures with pure “craniofacial separation” are quite rare, they are discussed in Panfacial Fractures (see below). Most Le Fort III fractures involve various levels of Le Fort injuries, as well as zygomatic and orbital fractures. Accordingly, they are discussed under those headings.

ZYGOMATIC FRACTURES

Zygomatic (or malar bone) fractures are the second most common fracture of the upper face following nasal fractures. Although these have classically been described as “tripod” fractures, perhaps better terminology is malar or zygomatic fractures, as the fracture is actually a quadrapod-type of fracture. The key components of the fracture include the lateral orbital rim attachment to the frontal bone at the frontozygomatic suture, a temporal extension across the zygomatic arch connecting with the temporal bone at the temporozygomatic suture, an infraorbital rim component attaching to the maxilla at the zygomaticomaxillary suture, and, finally, attachment of the maxilla along the lateral buttress as the zygomatic arch, as previously described with maxillary fractures. Another important component is the attachment to the sphenoid bone in the lateral orbital wall. Accordingly, one can consider a zygomatic fracture to have five important components when considering fracture reduction and fixation.

There are a great variety of zygomatic fractures types, but a simple system is to consider them as three different types of severity. A type I fracture is a minimally or nondisplaced fracture with no comminution. A type II fracture consists of much more displacement with minimal comminution. A type III fracture consists of significant displacement with severe comminution. The comminution in the type III is generally along the infraorbital rim, lateral buttress, and zygomatic arch. Both type II and type III fractures commonly have an infraorbital component that will be discussed shortly. A final type of zygomatic fracture is the isolated zygomatic arch fracture.

Although the most common concerns associated with zygomatic fractures are related to malposition, creating a cosmetic deformity, and the associated orbital involvement, which may result in globe malposition and visual changes, other functional impairments may occur. An almost obligatory numbness of the cheek and lip occur because of the location of the fracture in or near the infraorbital foramen (and infraorbital fissure), thus contusing (and occasionally severing) this nerve. The zygomatic arch may impinge upon the coronoid process of the mandible, causing both pain and, on rare occasion, actual impingement of the coronoid such that opening the mouth becomes difficult.

In terms of counseling patients with zygomatic fractures, it is important to note that there are a tremendous variety of ways in which to manage these fractures. Although the literature is full of “definitive” treatment methods of different types of fractures, there is no absolute algorithm for treatment of any type of zygomatic fracture. Suffice it to say that some nondisplaced or minimally displaced noncomminuted fractures may do quite well with no treatment, and, conversely, fractures with significant comminution and displacement, particularly when assessing the facial fractures, should be repaired. Similarly, the amount of internal fixation necessary for sufficient maintenance of reduction is also controversial. Accordingly, one should take a case-by-case approach to these problems while considering a variety of factors. Although the aesthetic concerns of dealing with a depressed malar eminence are very important, perhaps more important is the postoperative globe malposition (see Orbital Fractures, below). Other important aspects of counseling include that the patient should actively open the mouth during the first 4 to 6 weeks to prevent any scar contracture in the region of the coronoid process due to injury-caused inflammation in the zygomatic arch region, and the patient should be told that the sensation in the cheek region generally returns in about 3 months after the injury.

The repair of zygomatic arch fractures is somewhat controversial. The problem with the arch fractures is that they are commonly comminuted and depressed, thus leading to a potential concave deformity in the lateral

cheek region as well as potential impingement on the coronary process. The options for treatment are either to do nothing or to reduce the fracture and possibly fixate it. The most common approach for fracture reduction is the Gillies approach, which can also be used for reduction of the zygomatic body fracture. In this approach, an incision is made in the temporal hair-bearing region of the scalp with an incision through the skin and subcutaneous tissue and eventually through the deep temporal fascia onto the temporalis muscle. Blunt dissection inferiorly on this muscle to the area medial to the zygomatic arch is performed. At this point a blunt instrument, ideally a Gillies elevator that is specially designed for this purpose, is then used to reduce the fracture using bimanual palpation (Fig. 4-75). In most cases the fracture remains relatively reduced. Once reduced, an external splint can be placed over the region and secured, with the hope that the bone will stay in place, preventing the possibility of contour deformity or coronoid impingement. In some cases the fracture does not stay reduced, and it is in this situation that some surgeons place packing in the wound deep through the arch to maintain reduction for a period of time. If the packing is of a removable type (e.g., a Penrose drain) it is removed in about 1 week. An alternative is to place resorbable hemostatic material, which need not be removed. An alternative approach to reduction is the Keen or buccal-sulcus approach.

Although some surgeons have advocated open approaches to isolated zygomatic arch fractures by

performing the coronal incision, most feel that this is excessive for this type of fracture. However, endoscopic-assisted approaches via preauricular and temporal incisions recently have been described, which allow for placement of internal fixation devices. This might be the treatment of choice for those unstable fractures that continue to displace despite attempts at indirect reduction.

In terms of reduction of zygomatic complex fractures, both the temporal and intraoral approaches have been utilized. Another approach is placement of a percutaneous T-shaped screw reduction device. In type I non-comminuted and minimally displaced fractures, this reduction may provide adequate treatment. However, one may choose to provide minimal fixation in such cases. Perhaps the invasive form of fixation is via a trans-buccal incision, where after reduction of the fracture and using palpation of the infraorbital rim as well as direct utilization of a reduced lateral buttress, a single miniplate is placed on the lateral buttress component of the fracture, just as has been described in treatment of maxillary fractures. As fractures become more displaced or more comminuted, reduction issues become of paramount importance and more aggressive exposure is needed. In the older literature on this topic, alignment at the frontal zygomatic fracture line had been stressed, and some articles even stated that single plate fixation at this fracture site is adequate. Unfortunately, one can have excellent alignment at this fracture site along the lateral orbital rim, which has significant displacement throughout the rest of the zygoma. This is because the frontozygomatic fracture acts merely as a pivot point and does not give much information as to the alignment and reduction of the remainder of the fracture point.

Perhaps the most overlooked yet extremely valuable component of the zygomatic fracture is the displacement of the lateral orbital wall fracture (Fig. 4-54). This is particularly the case in less comminuted fractures where the lateral orbital wall in the region of the zygoma and sphenoid can be visualized. Through the lateral orbital approach (upper eyelid, eyebrow, or coronal approaches), one can dissect out the lateral orbit and, if it is not comminuted, the zygomatic portion of the lateral orbital wall can often be precisely aligned with the solid sphenoid component of the lateral orbital wall. This alone will often translate into realignment of the entire zygoma. In more comminuted fractures, involving the lateral buttress, infraorbital rim, and the zygomatic arch, this landmark becomes a less reliable region for determining alignment, particularly when the lateral orbital wall is comminuted as well. In the latter fracture scenario, the reduction becomes tedious and much more subjective. However, one can generally put the pieces of the comminuted puzzle into position and gain reference to the precise orientation and position of the zygoma. It is rare in an isolated zygomatic fracture, even if it is severely comminuted, that all fragments of bone cannot be

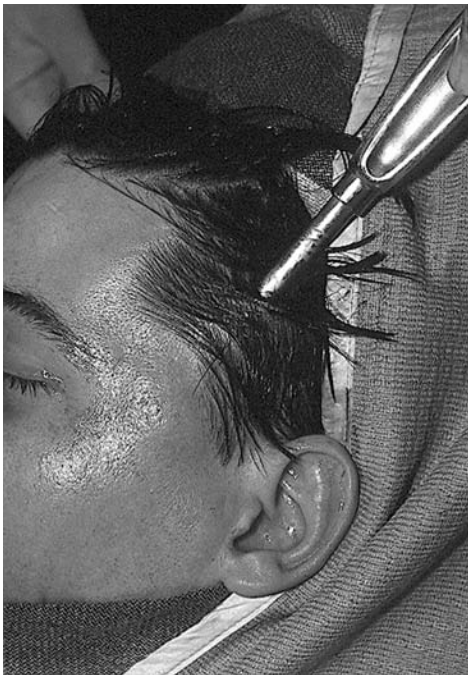


FIGURE 4-75 The temporal (Gillies) approach for reduction of an isolated arch fracture or a zygomatic body fracture. The approach is deep to the superficial layer of the deep temporal fascia immediately overlying the temporalis muscle.

located, resulting in the need for bone grafts. In most cases, adequate exposure to allow for proper anatomic alignment of the zygoma can be obtained with the combination of buccal sulcus, lower eyelid, and upper tarsal crease incisions (or a transconjunctival incision with lateral canthotomy).

In the rare case that adequate reduction is still uncertain after the above approach, a coronal approach is used to precisely realign the orientation of the zygomatic arch so that the comminuted segments of the infraorbital rim and lateral buttress can be aligned with greater confidence. However, with experience, the requirement for this more aggressive approach rarely becomes necessary. A commonly missed combined fracture scenario exists when there is a displaced zygomatic fracture in combination with the previously described nasomaxillary fracture. In this situation, a segment of nasal bone and superior-medial maxilla, along with the medial infraorbital rim, is displaced inferiorly and medially. Unless this nasomaxillary fracture is reduced to the appropriate superior and lateral position, there is a tendency to fixate the infraorbital rim at too low a level. This then translates to inferior malpositioning of the zygomatic body and orbital floor, potentially resulting in malar malposition and increased orbital volume, which may manifest as enophthalmos or hypophthalmos. Thus, it is very important to determine the presence or absence of this type of common fracture (often appearing as a simple nasal fracture) and treat it accordingly.

PITFALL... Note the existence of a nasomaxillary fracture, often masquerading as an isolated nasal fracture. Inadequate reduction of this fracture may result in poor reduction of the associated zygomatic segment.

In terms of adequacy of fixation, this procedure remains quite controversial (Fig. 4-76). As stated previously, some surgeons believe that single-plate fixation of the frontozygomatic fracture region is adequate in simple zygomatic fractures. Perhaps a better place for a single plate in such fractures is along the lateral buttress in the form of a stable miniplate, although a smaller plate may be adequate in a simple fracture. As fractures become more comminuted, the increased need for fixation becomes apparent. Smaller profile and size plates (1.0- to 1.3-mm screw size) are required for the frontozygomatic and infraorbital fractures. These smaller plates can even be used in comminuted fractures to bridge the comminuted gap and have the advantage of being less palpable through the skin.

It should be noted that as the functional loads are minimal across the various components of a zygomatic fracture, it appears that even smaller plates can withstand the average muscle pull placed on the inferior aspect of the zygomatic body. Although strength may be sacrificed,



FIGURE 4-76 A model demonstrating the use of microplates along the frontozygomatic and infraorbital fractures and a larger L-shaped plate along the lateral buttress.

using smaller, low-profile plates and screws decreases the palpability of these fixation devices through the very thin infraorbital and lateral orbital skin. A plate of any size can be used for the lateral buttress fracture, as it is rarely palpable. As will be discussed later, when a zygomatic fracture is a component of a Le Fort III or panfacial fracture, the requirements for larger plates at both the lateral buttress and the frontozygomatic region become apparent as a greater functional load is present. Conversely, in isolated fractures, judgment should be used as to the amount of fixation required, as personal preference and experience may dictate the best combination of approaches and fixation. It is important to note that plates are not required at each fracture site in all cases.

PITFALL... Even very low profile plates may be palpable through thin infraorbital and lateral rim soft tissues.

ORBITAL FRACTURES

The topic of internal orbital fractures is a significant one and worthy of the texts that have been written about it. This section reviews the current prevailing opinions on evaluation and surgical approaches for exploration and reconstruction.

As stated in the soft tissue evaluation section, one should have a high suspicion for an orbital fracture if the

patient has a history of an injury around the globe or if there are initial findings of periorbital ecchymosis or conjunctival hemorrhage. Similarly, the history of cheek numbness may suggest injury to the infraorbital nerve and fracture along the orbital floor. Workup includes ophthalmologic evaluation both for intraocular damage and for muscle entrapment. Findings such as a hyphema of the anterior chamber of the globe may limit the ability to proceed with repair of any intraorbital fracture. Accordingly, ophthalmologic evaluation is of great importance both for optimal patient care and for medicolegal purposes.

PEARL... An ophthalmologic exam is essential in all suspected orbital fractures, not only to assist in the evaluation of globe motility, but also to determine if there is any underlying globe injury.

In terms of classification, fractures can be thought of as pure internal orbital fractures (“blow-out” fractures) or combined internal fractures with external orbital framework fractures (combined with zygomatic or nasoethmoid fractures). Furthermore, the internal fractures can be considered as orbital floor fractures (both medial and lateral to the inferior orbital fissure), medial wall fractures, or lateral wall fractures. Most commonly, the orbital fractures represent a combination of several of these components.

Along with the physical examination, the evaluation includes axial and coronal CT scans. The axial CT defines the fracture components of the medial and lateral orbital walls, whereas the coronal CT further delineates the fractures of the orbital roof and orbital floor region. Sagittal reformatted reconstructions can also be very useful.

Understanding the pathophysiology of the various types of orbital fractures is essential in performing adequate evaluation and appropriate treatment. Most important is the orbital floor component. Isolated medial wall fractures are generally not of great significance and can generally be observed. However, when combined with even a limited medial floor fracture, such medial wall fractures can become significant. Addition of a greater orbital floor component increases the significance and the chance for postoperative enophthalmos or hypophthalmos if left untreated. The orbit should be thought of physiologically as a pyramid such that the apex of the pyramid is located posteriorly, superiorly, and medially. This cone shape functions to hold the orbital soft tissues, including the globe extraocular muscles, the surrounding orbital fat, and the suspensory ligament system, in proper position relative to the orbital cavity and orbital rims. When a fracture of significance occurs, there is a loss of the normal upward slope to the orbital apex such that there is a flattening of orbital floor. Such inferior displacement of the orbital floor leads to increased orbital volume, with potential herniation of orbital soft tissues and future enophthalmos or hypophthalmos (Fig. 4-77).

Equally important in these fractures is the possibility of injury not only to the globe but also to the surrounding extraocular muscles and nerves that supply them. In the evaluation of these patients, if diplopia is present and signs of globe movement limitations are present, suggestive of extraocular muscle restriction, it is critically important to determine whether or not there is an acute muscle entrapment. Such extraocular muscle entrapment is one of the few absolute indications for orbital exploration and repair. It should also be treated with urgency, as bone impingement on the muscle and nerve supply

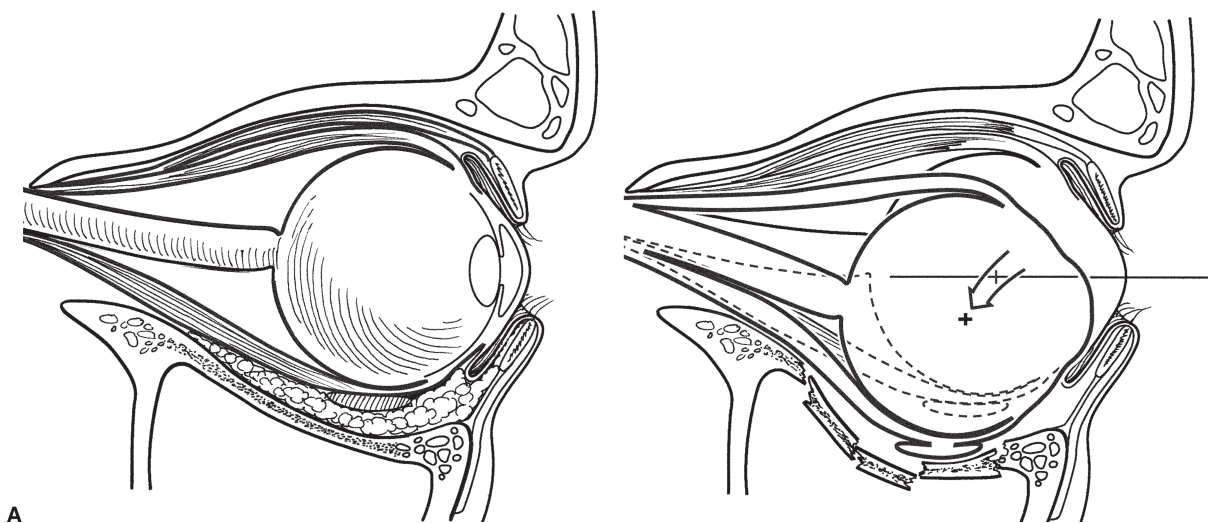


FIGURE 4-77 These sagittal diagrams in the orbit demonstrate the importance of the pyramidal shape of the orbit, with the floor sloping upward (A). A small bulge is present in the retro-orbital region along the medial aspect of the orbital floor. (B) The potential affect of globe movement posteriorly and inferiorly with loss of this upward slope and convexity.

can lead to a permanent injury that may require a later strabismus surgery. Of particular concern are “trapdoor” fractures of the orbital floor in which a fracture has occurred and snapped back into an apparently normal position. This is particularly a concern in the softer bone of the pediatric patient.

CONTROVERSY

Indications for exploration and repair of orbital fractures are diverse and inconsistent throughout the literature. Agreed-upon indications include extraocular muscle impingement and globe malposition on exam.

Exposure is of critical importance for appropriate exploration and repair. This generally requires at least a lower eyelid incision and commonly is combined with an incision that allows access to the lateral orbit. Occasionally, access to the medial orbit is required as well, and this may be performed in combination with the transcaruncular approach or, in severe cases, the coronal approach. The key to these approaches is the careful and often tedious dissection of the periorbital and the surrounding injured and prolapsed orbital soft tissues so that one can retrieve these tissues and retract them back into the orbital cavity (Fig. 4-78). After obtaining exposure of the infraorbital rim, the dissection plane is chosen in the least injured portion of the orbit such that a true subperiorbital plane can be established, often along the inferolateral orbital wall. The elevation then proceeds toward the fracture margins with careful elevation of the prolapsed tissues. Special retractors can be helpful to maintain retraction of the retrieved soft tissues.

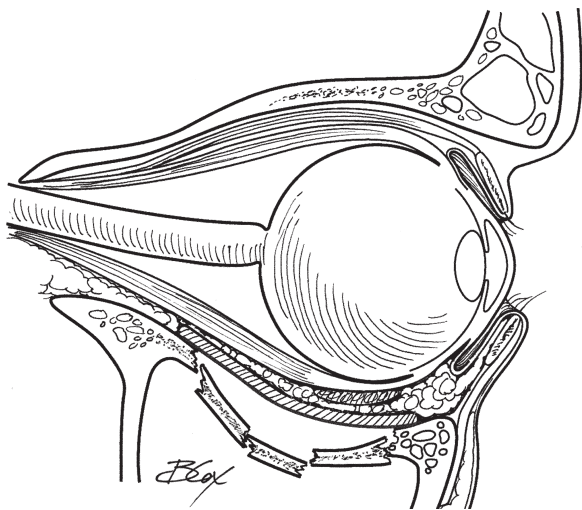


FIGURE 4-78 After placement of an implant to bridge the orbital floor and wall defects, the orbital contents are elevated and pushed forward.

Key to successful repair is location of stable bone edges in the lateral, posterior, and medial orbital walls. It is on these ledges that the posterior, medial, and lateral portions of the orbital reconstruction implant are positioned. If these ledges are not located, the orbital reconstruction may fail, as the implant material may be positioned without adequate closure of the increased orbital volume. As shown in the approaches portion of this section on facial trauma, a bony ledge must be clearly visualized and palpated.

While sustaining retraction of the dissected orbital contents, the reconstruction implant is positioned onto these posterior bone ledges and just inside the inferior orbital rim. No matter which type of material is chosen, it should be secured anteriorly with screws or plate fixation or suture fixation in some cases.

PEARL... Location of solid, nonfractured bony ledges in the posterior lateral and medial orbit is critical in allowing adequate reconstruction of the fractured orbit.

Implant choices remain quite controversial. Pliable smooth implants such as silicone sheeting have been traditionally favored by many surgeons. The problem with these implants is that because a capsule forms around them, a potential space exists for either a seroma or even an infection at a later stage. These are quite unusual but present a potential problem. Other alloplastic materials that have been successfully used are various meshes (Fig. 4-79) and porous types of implants (e.g., porous polyethylene, Medpor, Porex Surgical Inc., College Park, GA). The advantage of such mesh implants is the lack of capsular formation. However, they are more difficult to work with in terms of pliability, and some surgeons

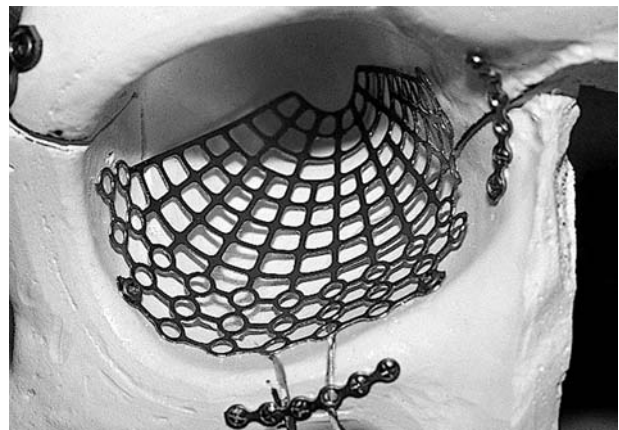


FIGURE 4-79 A model demonstrating the use of a titanium orbital plate secured along the lateral orbital rim. Note the upward orientation of the plate being positioned over the dissected solid posterior bony ledge.

believe that secondary procedures present a more difficult dissection. The same can be said for the use of titanium mesh implants that come in various shapes and sizes for the use of the orbital cavity. Finally, the use of bone grafts, particularly from the calvarium, remains popular because of their autogenous source (Fig. 4–80). Despite this advantage, bone grafts tend to be difficult to work with because of their solid nature. They also have a tendency to resorption. These alloplastic meshes and bone grafts are probably necessary with large, multiple wall orbital defects. Other implant materials such as septal and conchal cartridges have also been described, but are limited to small and medium-size defects of the orbital floor.

Besides the requirement of securing these implants, one should also check for normal extraocular motility after placing the implants. It is readily possible to impinge on soft tissues during the placement of the implant into the orbit. Similarly, the posterior extent of these implants must always be visualized. As many fractures extend deep into the orbit (up to 35 mm or more), the orbital apex is nearby and there is always risk to the injury to the optic nerve. Accordingly, visualization of the posterior placement of the implant is of critical importance.

CONTROVERSY

The type of implant material for orbital reconstruction remains debatable, but regardless of the material, the posterior extent of the implant must always be visualized.

Recent advances in endoscopic surgery are proving to play a role in orbital repair. Endoscopic-assisted visualization through standard eyelid approaches or through the maxillary antrum can be quite useful in confirming both the adequacy of dissection and proper implant placement.



FIGURE 4–80 The use of a calvarial bone graft in the orbit (arrows). Note the upward orientation of the posterior aspect of the bone graft.

NASAL AND NASOETHMOID FRACTURES

Blows to the central regional face can create not only nasal fractures but also fractures to the structures associated with the nasal bones, including the medial orbital region and canthal attachments of the eyelids. Similarly, the frontal sinus and skull base can be involved in such fractures.

Isolated nasal fractures can be thought of in terms of both a bone and a septal component. Accordingly, one should evaluate the integrity of the bony nasal pyramid (the nasal bones and nasal/frontal process of the maxilla), the cartilaginous middle third of the nose (the main body of the nasal septum), and the distal third of the nose (caudal septum and the lower lateral cartilages). This can be performed with simple digital palpation. Most descriptions in the literature focus on the displacement of the bony nasal pyramid, emphasizing closed reduction of these bony components. However, most fractures, particularly when there is a lateral blow to the nose, consist of fracture displacement not only of this bony pyramid but also of the cartilaginous middle third of the nose. Furthermore, with severe frontal blows, there may be telescoping of the entire bone and cartilaginous framework. Once again, it is extremely important to evaluate whether there is associated nasoethmoid involvement.

In most cases without an associated nasoethmoid involvement, attention can be placed on treatment of the nasal fracture itself. When performing a closed reduction, adequate anesthesia is extremely important because without it the stress of the situation increases, and an uncooperative patient may lead to an unsatisfactory result. Although adequate anesthesia can potentially be obtained using topical anesthetics followed by injection of local anesthetics, many surgeons prefer to use the same techniques with the addition of intravenous sedation.

When performing a closed reduction of a nasal fracture, one must first evaluate the septum for septal hematoma, which, if present, should be drained appropriately. In the case of a bony displacement of the external nose, a special elevator shaped like a blunt butter knife can be useful for reduction. This instrument is placed intranasally to a controlled depth as measured on the external nose prior to insertion, followed by disimpaction of the fractures. Reduction of the fractured bones by bimanual palpation using fingers and the elevator is then accomplished.

The concept of open reduction of nasal fractures remains controversial. Closed approaches can occasionally straighten a combined bony and cartilaginous fracture. However, one should be prepared for a limited open repair of the cartilaginous septal fracture. In such an open repair, minimal cartilage and bone is removed. The key to straightening the cartilage in the open repair is exposure of the fracture component that is often telescoped or buckled, followed by reduction of the septal

fracture toward the midline, then placement of transseptal figure-of-eight mattress sutures between the cartilaginous fracture fragments. The latter both realigns the displaced fracture components as well as offers some resistance to the fracture edges, keeping them from dislocating postoperatively. The mucoperichondrial envelopes are then reapproximated with an absorbable quilting suture.

The most difficult form of nasal fracture is that which results from a direct anterior blow to the nose. This often results in severe bilateral telescoping of the nasal pyramid and telescoping of the bony and cartilaginous septal framework. Such a fracture is extremely difficult to repair without open reduction and, even when this is performed, it often results in an unsatisfactory repair with flattening and shortening of the nose. One should be prepared for a relatively early open reconstruction of such noses to lengthen and augment them appropriately, prior to skin/soft tissue contraction.

As will be discussed with nasoethmoid fractures, severely comminuted nasal pyramid fractures often benefit from placement by external splinting devices, not unlike the old traditional lead splints used ineffectively in the past for nasoethmoid fractures. Any semifirm material with a soft tissue backing can be used. These splints are placed along the lateral sidewalls of the nose after reduction of the nasal fractures. A large, transnasal mattress suture is used to provide gentle yet firm bilateral compression on the implants. It is important not to overcompress the bones because soft tissue injury and scarring may result. This can often be very effective in providing narrowing of the severely comminuted fractures. Similarly, internal nasal splints may be useful in more severe fractures to maintain apposition of the mucoperichondrial envelopes to the reduced septal fractures.

With more severe blows to the central region of the face, the nasal fracture may be converted into a nasoethmoid type of fracture. When combined with panfacial fractures, it may be difficult to determine whether a nasoethmoid fracture is present. Regardless, one should always have a high suspicion for this injury with any significant swelling and obvious trauma to the midface. Telecanthus is often described in the literature as the hallmark for diagnosing nasoethmoid fractures, but it may be very difficult to visualize with the extreme edema that is usually present. The physical exam sometimes reveals crepitus in the medial canthal region. Telescoping upon palpation of the nasal dorsum may be present and is generally much worse than in an isolated nasal fracture. A variety of tests have been described to determine whether the medial canthus is damaged including the “pinch test,” in which one finger is placed along the medial canthus while the eyelids are pulled laterally. Looseness along the medial canthus may be very helpful in diagnosing the presence of an avulsed canthal tendon.

However, in many of these fractures, the medial canthal region is intact and will not move when it is pulled. Perhaps the most valuable exam is that in which a hemostat clamp is placed intranasally with the tip at the medial canthal region, and a finger is placed externally over the medial canthus. By manipulating this region with the end of the hemostat while simultaneously palpating the canthus externally, one can generally elicit movement if the nasoethmoid fracture is present. Conversely, no movement would be suggestive of a stable nasoethmoid and canthal region. Finally, fine-cut coronal and axial CT scans are required to assess the anatomy of this region. If there is a separation of large fragments in the medial orbit/canthal area, there is a better prognosis than if severe comminution is present, as will be described shortly. These scans also define the presence or absence of injuries to the surroundings of the frontal sinus and anterior cranial fossa floor as well as associated medial orbital injuries.

PITFALL... Use of the “bowstring” test during physical examination of the nasoethmoid region may result in a false-negative result if the canthus remains intact but there is a displaced fracture in the region.

As with other facial fractures, numerous classifications schemes exist. Perhaps the most useful is the one described by Markowitz et al,² in which the concept of the “central fragment” is introduced (Fig. 4–81). They demonstrated that many fractures involving the nasoethmoid region involve a large fragment of nasomaxillary bone along the medial orbital rim that is often displaced. Important to this concept is that the medial canthus generally remains attached to this fragment. Accordingly, in terms of management, one should theoretically be able to simply reduce this fracture and reestablish normal medial canthal position and inner canthal distance. With this classification scheme, a type I fracture is one in which this central segment is fractured with the medial canthal tendon still attached. In a type II fracture, there is some fragmentation, but the canthal tendon remains attached to a significant segment of bone. The type III injury represents a situation where the central fragment is very comminuted, and a canthal avulsion from the bone may be present.

Numerous surgical approaches to the nasoethmoid region have been described, including direct incisions. If a large laceration is present over the root of the nose, it may facilitate a repair. However, a coronal approach is advised instead of direct approaches not only because of iatrogenic scar avoidance in the highly visible periorbital region, but also as it facilitates improved visualization and repair of the fracture. During the approach it is important to be very careful not to convert a type I or

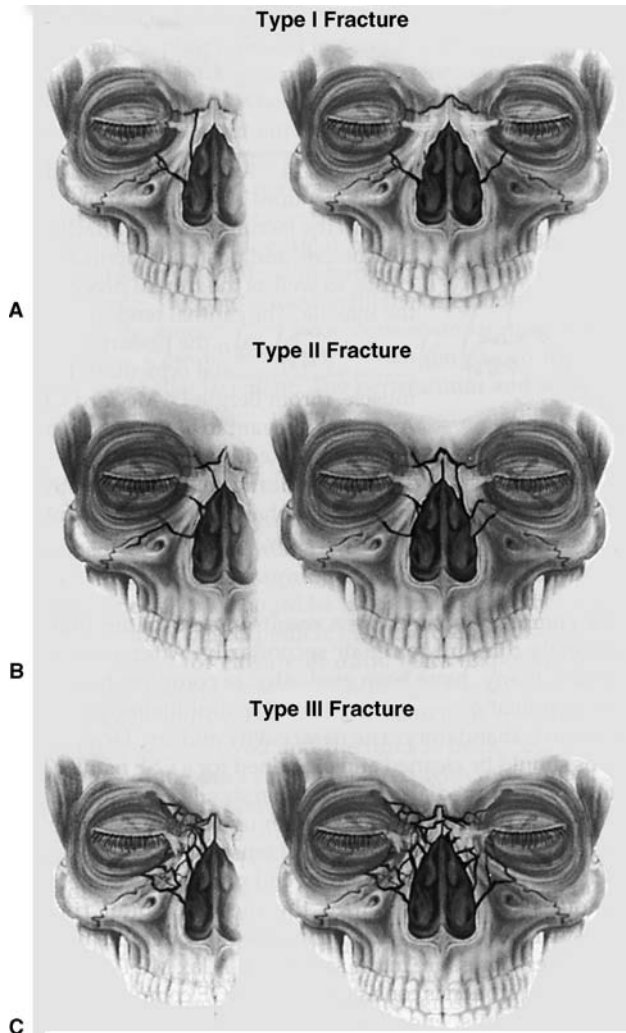


FIGURE 4-81 Nasoethmoid fracture classification. (A) Type I fractures involve a fracture of the central fragment of the orbital rim and nasal rim. (B) Type II fractures represent an increase in the degree of comminution, but the central segment remains of adequate size and maintains its canthal attachment. (C) Type III are severely comminuted with either a complete avulsion of the canthal tendon from the fragmented bone or the canthus remains attached to only a small portion of the bone.

type II fracture, i.e., situations in which the canthus is attached to a usable segment of bone, into a type III fracture where the canthus is avulsed. One should understand the anatomy of the canthus so as not to inadvertently strip the tendon away from an intact piece of bone during dissection of the medial orbit from above while using the coronal approach. During dissection of the medial orbit, a loose piece of bone is often identified below the frontal region and lateral to the nasal bones. Before dissecting further inferiorly, this bone is grasped with a forceps or hemostat and pulled medially (Fig. 4-82). While holding a finger externally over the medial canthus, one can determine whether this segment of bone is attached to the canthus. If the latter is



FIGURE 4-82 Cadaver dissection demonstrating the coronal approach to the nasoethmoid region. The end of the elevator is on the superior aspect of the right medial orbital central fragment with its attached canthus.

the case, no further dissection inferiorly should be undertaken. Attention is then turned toward identifying this segment of bone from below, either through the lower eyelid incision or through the buccal sulcus approach. Prior to fixating the fracture fragments into position, particularly in a type II fracture, the central fragment should be compressed medially with transnasal wires to the opposite central fragment, regardless of whether it is a unilateral or bilateral fracture (Fig. 4-83). It is important that this transnasal wiring be placed posterior to the canthus to achieve adequate narrowing. After this transnasal wiring has been placed to narrow and reposition the central fragments, microplating of the region is undertaken (Fig. 4-84). It is important to use small plates so that they are not palpable through the skin or contribute to apparent widening. Plates are generally required in the region of the nasal root onto the



FIGURE 4-83 After compression of the bilateral fractured central fragments with transcanthal wires. These wires are placed posterior to the medial canthal attachments.



FIGURE 4-84 Microplate fixation of the central nasoethmoid central fragments of nasal bones and medial orbital reconstruction with a titanium mesh plate.

frontal bone as well as along the medial orbital rim and occasionally the medial buttress of the nasal pyramid. Following fixation of the fracture, orbital reconstruction is facilitated by dissection on this medial orbital region.

Type III fractures, in which there is tendon avulsion, represent a completely different fracture scenario as the tendon is either completely avulsed or the tendon is attached to only a small, unusable piece of bone. In this case the tendon must be positioned anatomically so as to optimize the long-term appearance of the canthus. The key is to create a pull on the tendon that is more posterior and superior than normal as, with healing, the tendon

tends to move forward and downward. Creating such a pull can be quite difficult, although a variety of techniques have been described. A technique that seems to be quite helpful is removal of the dorsal nasal bony fragments. This allows clear visibility to the underlying intranasal structures. A hole is then drilled transnasally through the perpendicular plate of the ethmoid, remaining inferior to the cribriform plate, thus avoiding intracranial injury. The perpendicular plate, even if fractured, generally is present and will serve as a fulcrum for the wire being positioned posteriorly and superiorly. In the rare event that this perpendicular plate bone is not usable, another technique is to use a small plate suspended from a stable medial nasal structure that extends into the medial aspect of the orbit. Similarly, if mesh is used for reconstruction of the medial orbit, it can be used to place a wire through a hole in the plate or mesh to provide the posterior and superior fulcrum affect. These wires are then passed through the opposite side and brought through a separate hole in the contralateral medial nasal region and then twisted around this screw in the glabella region (Fig. 4-85). Traditional “intercanthal wiring,” in which bilateral canthal injuries are pulled toward one another, produces anterior pull and may result in an abnormal appearance to the canthal region even if adequate narrowing is achieved. When using this technique, each avulsed canthal injury is treated independently of the others. This appears to provide an improved effect in terms of adequate medial and posterior positioning. Because of the propensity for lateralization and inferior movement of the healed tendons, some surgeons are proponents of performing external ethmoidectomy at the time of this procedure.

PEARL... When repositioning the canthal tendons, there should be overcorrection medially, posteriorly, and superiorly.

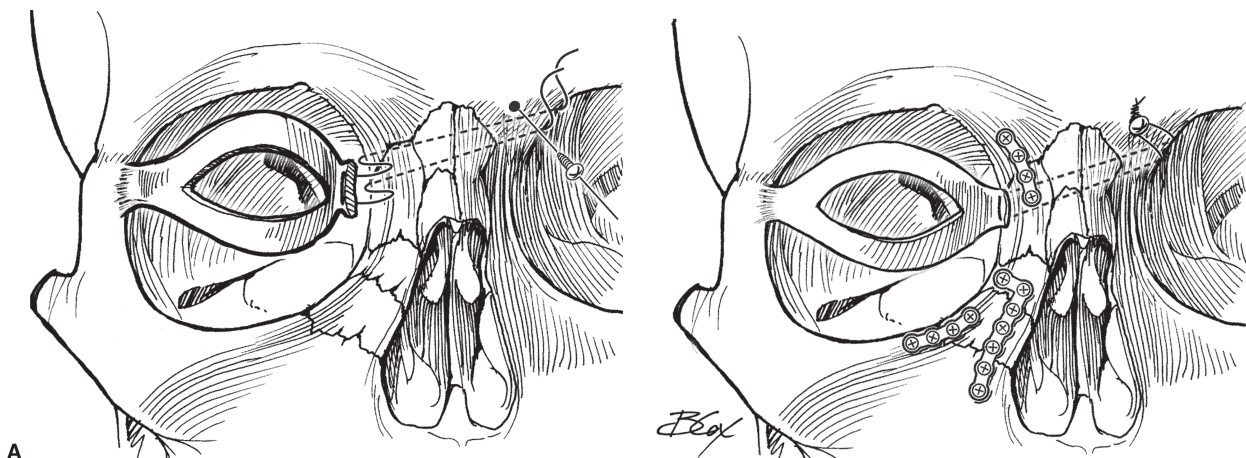


FIGURE 4-85 Depiction of reconstruction of a type II or type nasoethmoid fracture with a transcanthal wire suspension of the fractured right canthus. This wire fixation has a posterior and superior pole.

A final consideration in the treatment nasoethmoid fractures is the restoration of dorsal nasal support. This is important for two reasons. First, because of the severe comminution of both the bony pyramid and the cartilaginous septum, the nose can be foreshortened and will not support skin and soft tissue contraction during the healing period. This may result in a significantly overly rotated and underprojected nose. Such nasal deformities are extremely difficult to correct in the secondary setting. Second, this type of comminution, when left unabated, almost always results in nasal obstruction. Accordingly, in severe cases of comminution, structural reconstruction of the nose is very important using bone grafting materials. A calvarial bone graft is cantilevered from the region of the nasion (Fig. 4–86). It is important to place this graft distal to the nasion so as to avoid obliteration of the nasofrontal angle. A small plate is generally of adequate strength to maintain the graft in position. In this situation where the nasion is deep with a more acute nasal frontal angle, the grafts can be placed more proximally over the nasion and may be secured using the lag screw technique. In the fracture situation in which most of the injury is limited to the nasal bones and nasal pyramid, the graft can be short, with the reconstruction being limited to the bony dorsum. A more common situation is where there is complete loss of both bony and cartilaginous support due to both bony and septal comminution. The graft should extend to the tip region in these cases, with an attempt being made to place the contoured end of the bone graft deep to the domes of the lower lateral cartilages. Placing this bone graft results in the maintenance of both length and dorsal nasal projection, such that the contraction of the skin–soft tissue envelope during the lengthy healing phase will not overcome the underlying structural support. A potential benefit of

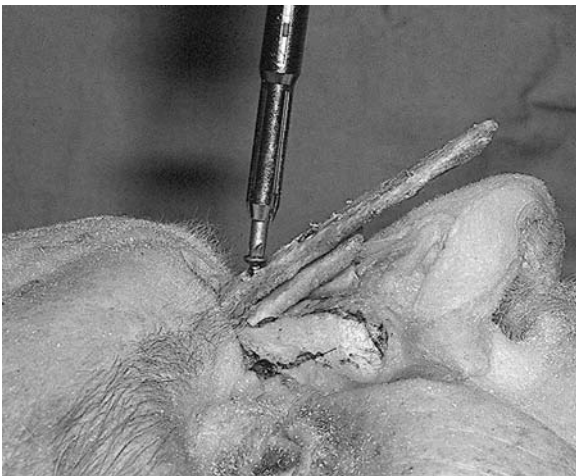


FIGURE 4–86 Profile photograph of a cantilevered nasal bone graft in a cadaver dissection. Lag screw fixation is used in this case, but plate fixation is optimal in most situations, to prevent blunting of the nasofrontal angle.

maintenance of dorsal nasal projection with the bone graft is that it often allows for an adequate nasal airway after the healing process is finished, particularly when the intranasal septal fractures had been reduced.

It should be noted that many of these injuries have significant intranasal mucosal lacerations that, if left untreated, will result in significant synechiae. Accordingly, large silicone sheets should be placed and secured along the nasal septum during the healing period.

FRONTAL SINUS AND FRONTOCRANIAL FRACTURES

Fractures in the anterior cranium often involve the frontal sinus and the surrounding frontal bone. They can also extend inferiorly and posteriorly along the anterior skull base. Accordingly, one must have an intimate understanding of the complex anatomic relationships of this region. The frontal sinus is the last of the sinuses to develop, forming as an evagination of the anterior-superior portion of the middle meatus or the frontal recess. It is absent at birth and becomes apparent at age 6 to 8. Ten percent of the population has only one frontal sinus and 4% has no frontal sinus. This evagination and formation of the frontal sinus is in the cancellous layer between the two bony cortices of the frontal bone. Accordingly, there is an anterior and posterior table of the frontal bone, both of which tend to be thin in nature. Because the embryologic origin is the frontal recess, the nasofrontal duct drains into the middle meatus. The sinus can be quite small in size or quite large, particularly in males with a large frontal boss. Interestingly, forces are transmitted more effectively through a small sinus, and these patients tend to have more associated frontal bone and cranial base injuries. Conversely, those with large frontal sinuses disburse the force more efficiently, resulting in more isolated anterior table fractures.

Functionally, the most important structures of the frontal sinus region include the nasal frontal duct, the sinus posterior table, and the anterior cranial fossa floor. The former is important because obstruction of a nasofrontal duct can lead to either acute infection or a chronic mucocoele. The posterior table and anterior fossa floor are important because direct communication with intracranial and intranasal cavities should not exist. Fractures that extend into the cribriform plate in combination with posterior table fractures may allow direct entry of nasal and sinus contaminants into the intracranial cavity. Accordingly, diagnosis of these fractures is extremely important.

CONTROVERSY

The key to proper evaluation and treatment of frontal sinus fractures involves appreciation of the potential problems created by injuries to the nasofrontal duct.

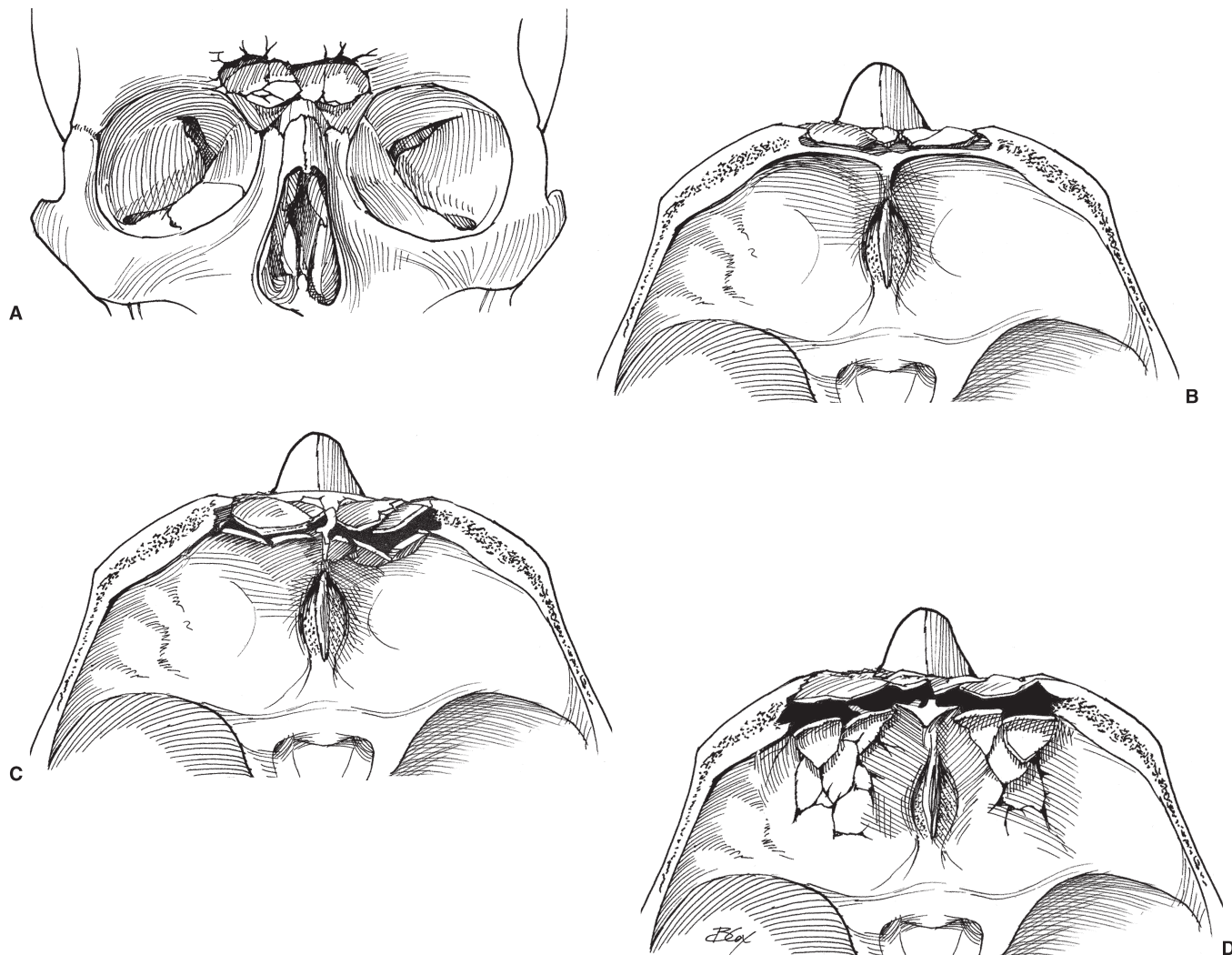


FIGURE 4-87 Classification of frontal sinus anterior and posterior table fractures. Demonstrated here are a comminuted anterior table fracture (A), a comminuted anterior and posterior fracture (B), and with associated sinus floor and anterior skull base fractures (C). These fractures can be linear, segmental and non-displaced or minimally displaced, comminuted with significant displacement, or with severe posterior table comminution and involvement of the anterior fossa floor in the region in the cribriform plate.

In terms of classification, the first category is anterior table fractures, which can be linear and nondisplaced or comminuted and displaced (Fig. 4-87). Key to the evaluation of anterior table fractures is whether or not the fracture continues into the nasofrontal duct or a segment of fractured bone has occluded the duct. The next category is posterior table fractures of the frontal sinus. It is uncommon that there is a significant posterior table fracture without an associated anterior table fracture, but it can occur. The posterior table fracture can be thought of as either linear or comminuted and displaced, non-displaced, or segmental. The literature states that posterior table fractures displaced more than 1 mm should raise the suspicion of possible dural brain injuries. It is important to remember that trapdoor types of fractures can occur so that even if displacement is not obvious, an intracranial injury may still exist. Finally, posterior

table fractures can be associated with fractures of the cribriform plate, anterior cranial fossa, and orbital roof. Besides the previously mentioned issues of intracranial contamination, inferior displacement of the lateral sinus floor can increase the pressure on the orbit and the globe.

Evaluation includes physical exam and CT scan. A frontal sinus fracture should be suspected with any frontal laceration as well as with obvious contour deformities, tenderness or crepitus, supraorbital nerve anesthesia, CSF rhinorrhea, and an associated nasoethmoid fracture appearance. Radiograph evaluation is once again by coronal and axial CT scans, which assist in identifying the fractures of the anterior and posterior table, although it is often difficult to clearly delineate fractures involving the nasofrontal duct.

Important to the entire perioperative process is counseling the patient, particularly when a conservative

therapeutic approach is chosen with no surgical intervention. Patients with frontal sinus fractures have a life-long risk of frontal sinusitis and the complications of mucopyocele, and intracranial abscess. Accordingly, they should seek medical attention with any symptoms remotely suggestive of frontal sinus problems so that a CT scan can be obtained.

CONTROVERSY

There is no one correct way to manage frontal sinus fracture, and management remains controversial. However, the goal should be a “safe” sinus, whether there is intervention or not.

After systematic evaluation of the fractures, the surgical plan can be coordinated. Isolated anterior table fractures can be observed if there appears to be no contour deformities. However, it is important to be certain that there is no suggestion of involvement of the nasofrontal duct by clarifying on CT that there is neither comminution of the duct region nor segments of bone in the duct itself. It should also be noted that because of edema that exists after injury, cosmetic depression may not become apparent until this edema subsides. Accordingly, if no immediate intervention is undertaken, the patient should be followed closely for contour deformity. Conversely, if there is an obvious depression of fracture fragments (Fig. 4-88), reduction and fixation should be undertaken. Unless there is a large laceration directly over the depressed fracture fragments, a coronal approach is optimal for fracture reduction and fixation. In this approach, the fracture is approached from above, followed by careful removal of the bony fragments from the periosteum (Fig. 4-89). The fragments of location should be carefully

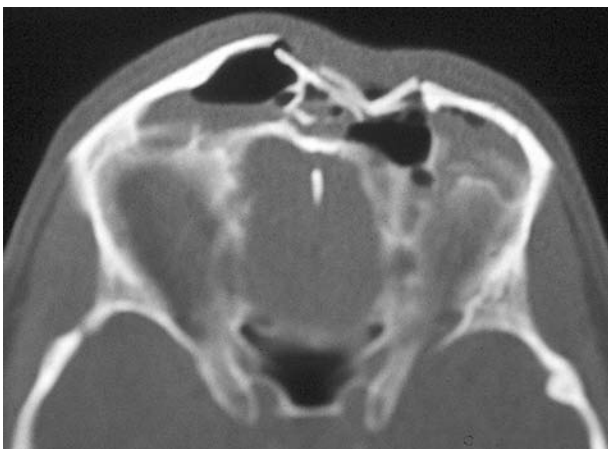


FIGURE 4-88 Radiograph demonstrating severe comminution of the anterior table in a large frontal sinus. Note the central component of the fracture and the inability to determine whether the nasal frontal duct is involved.

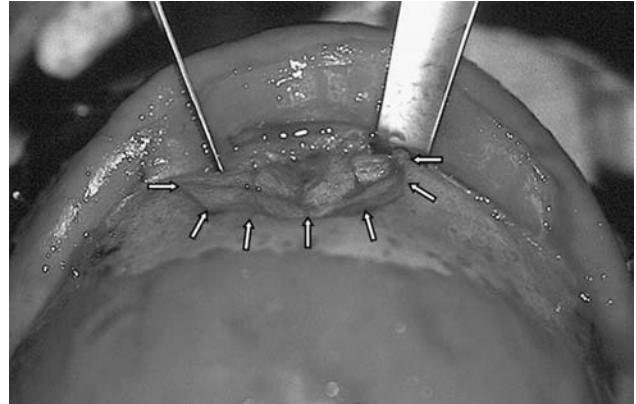


FIGURE 4-89 After coronal approach, severe comminution of the anterior table is noted (arrows). These fragments were removed and systematically labeled for later replacement. After irrigation of the sinus, it was noted that the nasal frontal duct was uninjured.

marked and even mapped on a piece of paper so that the “puzzle” can be put back together prior to replacing them. The sinus should be irrigated and carefully evaluated for other injuries. One should avoid overinstrumentation of the sinus, particularly the nasofrontal duct, as a safe sinus can be converted into a traumatized and potentially unsafe sinus with excessive manipulation in the siphon region into the duct.

The anterior table can be reconstructed with microplates or mesh. Often many of the fracture fragments are too small to be usable. Bone grafts from the calvarium can be substituted, or one can simply cover the entire region with titanium mesh (Fig. 4-90). More recently, hydroxyapatite cement has been used to restore contour to the anterior table. There have been recent reports in the literature of the use of endoscopic approaches for reduction and fixation of limited isolated anterior table fractures, but these approaches have not yet become the standard of care.

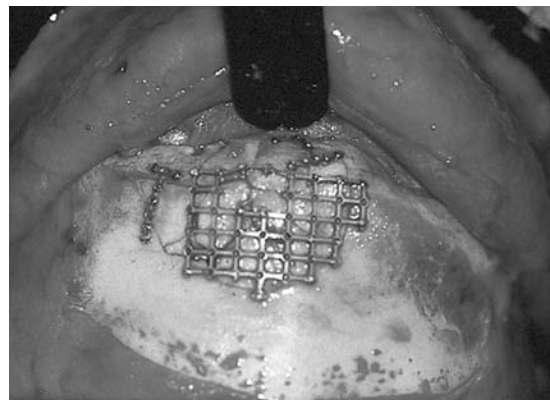


FIGURE 4-90 The use of titanium mesh and microplates to repair the anterior table.

In general, with posterior table fractures of any significance, it should be assumed that the nasofrontal duct is involved until proven otherwise. Other findings that may suggest this combination are intercranial air (which can also be from a small relatively insignificant cribriform plate fracture) or cerebrospinal fluid (CSF) rhinorrhea. The latter is a relatively unusual finding in the acute setting even with large defects such as edema, which in the region may block the exit of CSF. This rhinorrhea may not become present for days or even weeks after the initial injury. Accordingly, the absence of this finding should not be relied upon as a predictor of future problems. As a rule, a posterior table fracture can be observed if the displacement is less than 1 mm (or one posterior table width). However, when there is a CSF leak that persists longer than 1 week, intervention should be considered regardless of whether there is displacement. If the displacement is greater than 1 mm (or one table width), primary intervention should be considered. In the relatively rare scenario of a posterior table fracture without nasofrontal duct involvement (a diagnosis often made at the time of exploration), the posterior table can be carefully examined for CSF leak and any other signs of intracranial injuries. If none are present, the sinus can be preserved with simple reduction and fixation of the sinus wall. However, if the nasofrontal duct seems to be involved as evidenced by fracture displacement or mucosal maceration, and there does not seem to be significant intracranial injury in combination with the posterior wall fracture, the sinus should be obliterated. The obliteration process is well known and evolves from the treatment of chronic frontal sinus surgery. Although classic descriptions include the use of the so-called osteoplastic flap, this is rarely practical because the anterior table is commonly comminuted. Accordingly, subperiosteal dissection as was described with treatment of anterior table fractures is usually required. The fracture fragments are removed, and if adequate visualization of the entire sinus is not possible through this fragment removal window, an osteotomy is created to remove the remainder of anterior sinus wall. A 6-foot Caldwell radiographic view may be useful in this approach to create a template, which will guide the osteotomy. Similarly, the use of transillumination may also be helpful in determining where the bone cut should be placed. These segments are preserved and can be reconstructed on separate table during the obliteration procedure.

The next stage of obliteration is to completely remove the mucosa of the entire sinus and duct region. This can be difficult in a large sinus, especially those with narrow supraorbital extensions. Traditionally, the bone is burred after the mucosa is removed. However, this is an evolution from chronic sinus disease treatment and probably is not necessary. The next step of the obliteration procedure is closure of the nasal frontal duct. The goal at this point is separation of the ethmoid sinuses



FIGURE 4-91 The use of cancellous bone for obliteration of the frontal sinus after stripping of all of the sinus wall and duct mucosa along with obliteration of the nasofrontal duct with cortical bone.

from the soon-to-be-obliterated frontal sinus. Accordingly, a roof is created for the ethmoid sinus. Many materials have been used for this purpose, including fascia, muscle, and bone. Options for subsequent obliteration of the sinus are numerous. The use of abdominal fat, also borrowed from chronic sinus disease surgery, remains quite controversial, and many surgeons are inclined to use other obliteration materials. Autogenous materials include iliac cancellous bone (Fig. 4-91), cortical bone (calvarium), or even vascularized galeofrontalis or pericranial flaps. Rohrich and Hollier³ have popularized the concept of “spontaneous osteogenesis,” with the theory being that the most important part of the oblitative process is the obstruction of the frontal nasal duct. They have documented cases where the sinus has spontaneously obliterated itself with bone and scar formation. This remains controversial but certainly has merit. The recent popularity of obliterating the sinus cavity as well as the nasal frontal duct with hydroxyapatite cement has met with mixed success, but certainly appears to be an acceptable approach (Fig. 4-92).

CONTROVERSY

Obliteration of the frontal sinus, when it is indicated, and which materials to use are likely always to be very controversial topics.

PITFALL... Many different materials have been used for sinus obliteration. Failures are probably not a result of the material used, but rather inadequate obliteration of the nasofrontal duct.



FIGURE 4-92 Hydroxyapatite cement being use for obliteration via a preexisting large "Y"-shaped laceration.

A final method for management of frontal nasal duct injuries is intubation of the duct by placing a small plastic tube (e.g., an endotracheal tube) from the frontal sinus, through the duct, and into the nose. For it to be effective, the tube should probably remain in place for about 4 to 6 months, causing significant patient morbidity. Although this remains a controversial method of management, newer tubes and techniques that are borrowed from modern endoscopic frontal sinus management may play a role.

When there is significant comminution of the posterior table, particularly with evidence of dural tears and intracranial injuries, the treatment of choice is sinus craniatization. In this procedure, the posterior table of the frontal

sinus is completely removed followed by removal of all residual mucosa of the sinus floor, anterior table, and nasofrontal duct (Fig. 4-93). In principle, duct obliteration separates the ethmoid sinuses from the intracranial cavity, whereas the brain is allowed to fill the void created by removal of the frontal sinus. The latter is not likely to occur, but it does not seem to cause any problems. Regardless, some surgeons promote obliteration of this dead space with autogenous materials. Because of the concern for creation of a watertight seal between the anterior fossa floor (with the underlying ethmoid sinus) and the intracranial contents, a pericranial flap is occasionally used for additional support and separation of these cavities.

In more significant injuries, such as those with gunshot wounds where an avulsion injury has occurred in the anterior cranial fascia and base of the frontal sinus, bone grafts may be used to reconstruct the floor with or without placement of a pericranial flap. Once again, the key is obtaining a watertight seal with separation of the ethmoid sinuses and anterior cranial fascia. More recently, some surgeons have been using hydroxyapatite cement for the same purpose.

The final type of injury involving the frontal sinus and frontal bone is a fracture with displacement of the superior orbital rim and superior orbital roof inferiorly into the orbit. If the physical exam or CT scan is suspicious for such an injury, ophthalmologic evaluation should be obtained immediately to determine if there are signs of increased intraocular pressure. If the latter is the case, the fracture should be reduced and repaired emergently.

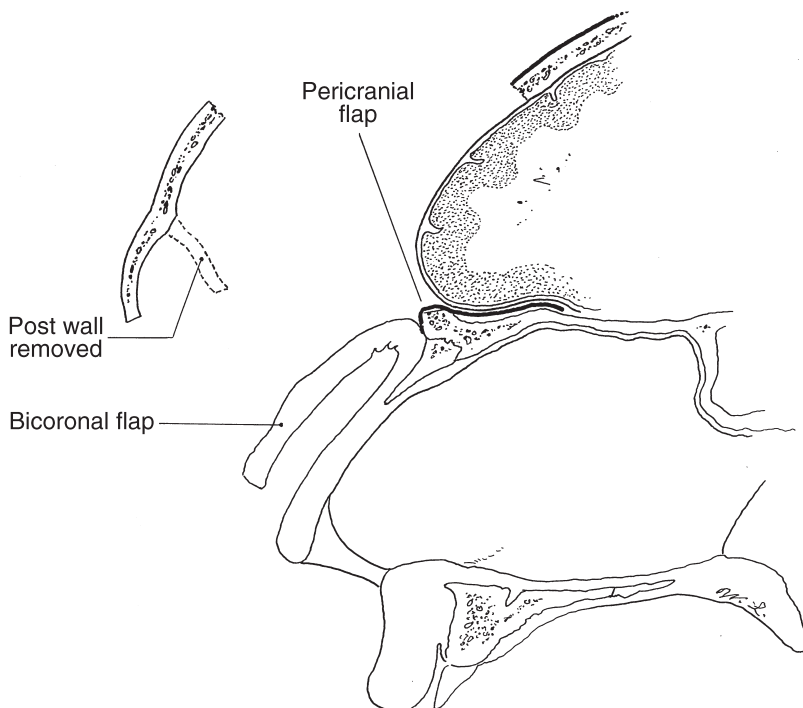


FIGURE 4-93 A schematic of the craniatization procedure. After removal of comminuted anterior and posterior table segments, the mucosa is completely removed from the anterior table and sinus floor while the posterior table is removed. A pericranial flap is rotated into position extending onto the anterior cranial fascia floor in the region posterior to the cribriform plate.

PANFACIAL FRACTURES

By definition, panfacial fractures involve fractures of numerous regions of the face, most commonly the mandible, maxilla/midface, orbits, and zygoma. They may include nasoethmoid and frontal sinus or cranial fractures as well. Similarly, as panfacial fractures are commonly the result of high-energy forces, multisystem trauma is generally present. These fractures present a very difficult evaluation and management problem, and have been the source of extensive discussion as to the optional way to approach them. One must remember that the reduction of one fracture will greatly impact the fracture reduction adjacent to that fracture. Accordingly, precise reduction with appropriate fixation is the key. Traditionally, multiple fractures to the face are managed by placement of the patient in MMF and then proceeding with reduction of the fractures. It is now believed that traditional wire fixation techniques are probably not adequate because of the problems of shortening of the face, particularly in the posterior dimension, which commonly leads to an open bite deformity as well as widening of the face.

Because of the persistent problems with these traditional techniques, two schools of thought have evolved in terms of optimal panfacial fracture management. The first is that espoused by Gruss and Stanley (Figs. 4-94 and 4-95). In this situation the fractures are repaired from outside to inside (or stable to unstable) in a sequential

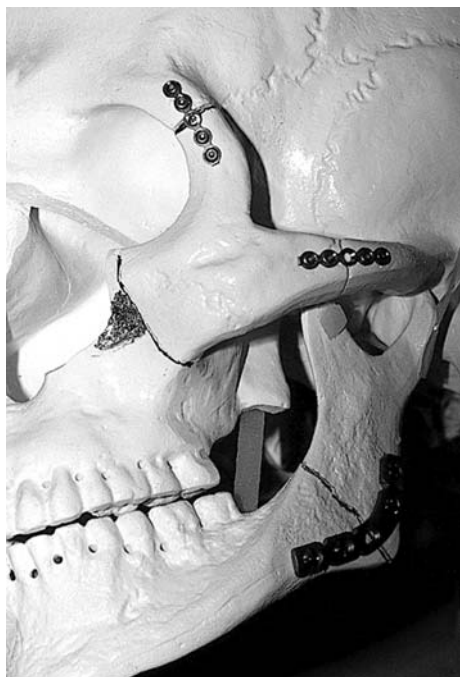


FIGURE 4-94 The use of the “stable to unstable” sequence for panfacial fracture fixation. This model demonstrates the initial repair of the lateral facial fractures, including the zygomatic arch, frontozygomatic, subcondylar, and angle fractures.

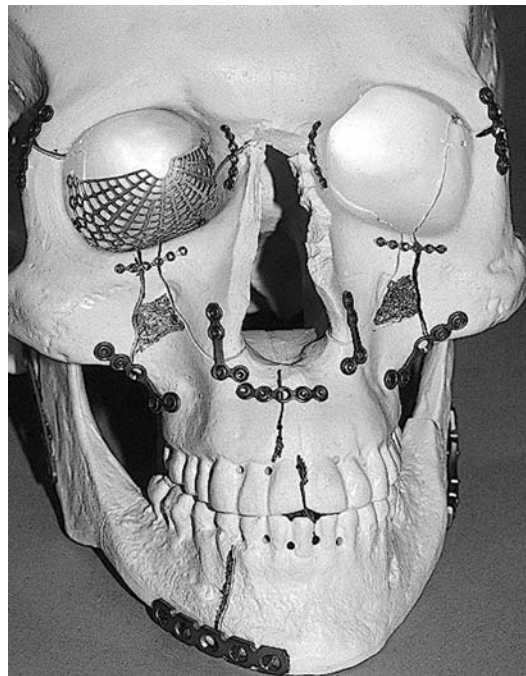


FIGURE 4-95 After repair of the lateral panfacial fractures, the central fractures are repaired in the midface and anterior mandible. This is followed by orbital and nasoethmoid repairs.

fashion. The zygoma is initially fixated at the frontozygomatic and temporal (zygomatic arch) fracture points to “suspend” it from the skull base and frontal cranium.

Of critical importance in this initial stage is proper orientation of the zygomatic arch, with the alignment creating a flat structure rather than a curved arch. This initial step creates the proper projection and width for eventual suspension of the midface. Simultaneously, the lateral mandibular fractures are repaired. It has become quite evident that subcondylar fractures in combination with severe midface and upper facial fractures should be reduced openly and plated. When there is an anterior mandibular fracture in combination with either unilateral or bilateral subcondylar fractures, there tends to be a splaying of the mandibular angles, thus creating an excessively wide mandibular width and dental arch. Accordingly, it is very important to use adequate fixation in the symphyseal or body fractures so as to maintain appropriate width. An important maneuver during reduction and plate placement is placement of pressure at both angles to ensure that there is adequate reduction of the lingual cortex of the mandibular body (Figs. 4-96 and 4-97). This reduction and fixation in the anterior mandible in combination with reduction of the subcondylar fractures should provide adequate narrowing of the mandibular dental arch when it is aligned with the maxillary dental arch. After the mandibular repair and initial reduction and fixation of the zygoma fractures, the next step is to repair the nasoethmoid region. At this point the correct facial

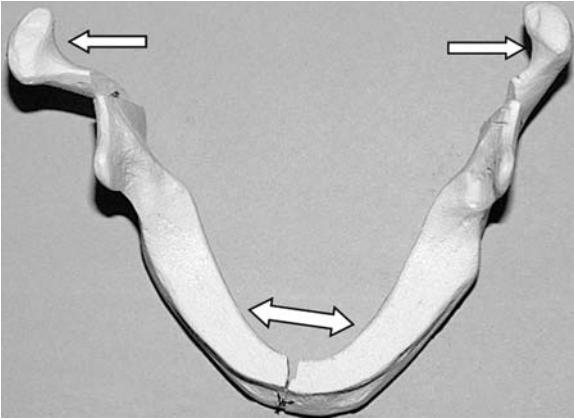


FIGURE 4-96 With fractures of the subcondylar region and anterior mandible, there is a tendency for splaying of the lingual cortex at the symphysis and the mandibular angles (arrows). It is important to place pressure along the mandibular angles to maintain reduction and fixation.

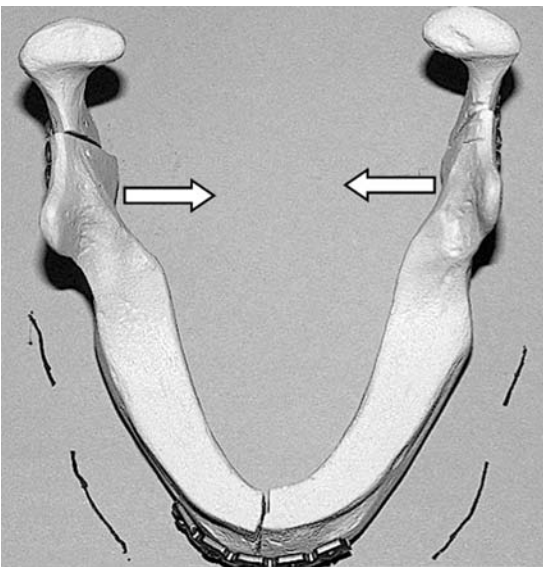


FIGURE 4-97 A strong, overbent symphyseal plate, in addition to reduction and plating of the subcondylar fractures, should allow for appropriate narrowing of the mandibular arch (arrows).

width as well as upper facial projection and contour should be reestablished. Additionally, the correct position of medial and lateral buttresses of the maxilla should also be present. The maxilla, at the Le Fort I level, can then be reduced and appropriately plated to the superior aspects of the medial and lateral buttresses by fixation. If a sagittal fracture of the palate is present, it should be repaired prior to Le Fort I level fracture fixation. The combination of these maxillary fixation procedures should establish the correct relationship of the maxillary dental arch.

The second approach to repair of panfacial fractures is promoted by Manson et al.⁶ They believe that the

face should be separated into a superior and an inferior division, with the inferior division consisting of the Le Fort I level maxilla and mandible, and the superior division made up of all structures above the Le Fort I level. They also describe a lateral zone consisting of the mandibular angles and condyles along with the lateral orbit and zygoma, and a central division consisting of the mandibular symphysis and body along with the maxilla, central midface (with the nasoethmoid region), and anterior cranium. Using this method of repair, the central craniomaxillofacial skeleton is repaired first, including reduction and fixation of the mandible fractures, the split palate, and the maxillary, nasoethmoid, and frontal sinus/central cranial fractures. This is followed by repair of the lateral skeleton, with reduction and fixation of the condyles and zygomatic fractures. The orbital fractures can be repaired when convenient. The maxilla is placed into occlusion with the mandible after repair of both the dental arches. Key to both of these panfacial fracture repair schemes is adequate narrowing of the dental arches and the upper facial skeleton. Accordingly, although there is movement away from stronger and bigger plates, their use should be considered where narrowing is required, such as in the anterior mandible and zygomatic arches.

PEARL... In panfacial fractures, use a larger plate in symphyseal fractures when there are subcondylar fractures present, as this helps prevent widening of the arch.

In general, the treatment of panfacial fractures requires significant degloving of many of the facial soft tissues. Accordingly, there is no place where facial resuspension techniques are more important than panfacial fractures.

An area of controversy in severe panfacial fractures is airway management. Traditionally, all patients with such fractures have undergone urgent elective tracheotomy. With improved methods of fracture management along with evolving endoscopic anesthesia intubation techniques, the indications for a tracheotomy are becoming less frequent. Tracheotomy is certainly indicated in patients with severe avulsion blast injuries to the mandible and maxilla, and in patients with severe intracranial injuries that may require prolonged ventilatory support. However, particularly in patients with isolated facial injuries or even with multisystem injuries in which it is unclear whether prolonged support is necessary, a standard orotracheal or nasotracheal intubation is possible. Although in the past the presence of a nasoethmoid or skull base fracture has been a contraindication to nasal intubation, the latter can safely be performed with fiberoptic guidance. Although the presence of a tube in the nose may make treatment of

nasal fractures and nasoethmoid fractures more difficult, it is certainly possible. However, when in doubt, a tracheotomy should be performed.

CONTROVERSY

A final area of controversy is the requirement for postoperative maxillomandibular fixation. Similarly, because of the acceptance of internal fixation for fracture repair, such maxillomandibular fixation may not be necessary following surgery (or the length of time it is required may be limited). This provides greater confidence for care of the patient postoperatively.

COMPLICATIONS OF CRANIOMAXILLOFACIAL FRACTURES

Although it is beyond the scope of this book to present an exhaustive review of facial fractures complications after management, they are reviewed briefly.

The most common complication of mandible fractures is malocclusion. Inadequate reduction of the fractures is the most frequent etiology for the problem, but inadequate or improper stabilization can also be a factor. Additionally, the misdiagnosis of fractures, such as missing a minimally displaced subcondylar fracture, can lead to malocclusion. The latter can potentially lead to shortening of the posterior vertical height, resulting in an anterior open bite. Secondary vertical ramus osteotomies or sagittal split osteotomies may be required for treatment of these deformities.

Malunion, nonunion, and infected nonunion can also occur with mandible fractures. The causes are often due to the use of inadequate fixation, particularly in comminuted fractures. However, any mandibular fracture can have these forms of unfavorable results. Infected nonunions are treated with intravenous antibiotics, often followed by aggressive open debridement and bone grafting. Traditionally, they have been treated with external fixation devices, but primary bone grafting after several days of antibiotics can be quite effective when combined with the use of a large reconstruction type of fixation plate. Nonunions and malunions are treated in a similar fashion.

Another problem with postoperative management is ankylosis of the temporomandibular joint, which may occur in condylar fractures even when apparently proper treatment has been provided. The key to prevention of such ankylosis is active physical therapy in the early postoperative phase. Although it is not commonly requested, such physical therapy assistance should be

considered. Temporomandibular joint ankylosis often requires open release of the ankylosis, debridement, and placement of a costochondral rib graft.

With maxillary and midface fractures the main problem is also malocclusion secondary to inadequate reduction. Surgeons tend to blame fixation devices for these poor results. However, the most common problem is not placement of adequate fixation, but rather poor reduction of the midface fractures. Another cause for malocclusion is inadequate structural support along a medial or lateral buttress. The cause is often comminution of the buttress with inadequate replacement of the comminuted bone fragments. Even miniplates may not withstand bite forces in the face of absent bone. Accordingly, primary bone grafts should be considered in such situations. Midface malocclusions require a Le Fort I level osteotomy, bone grafting, and fixation. Small malocclusions can sometimes be corrected with orthodontic appliances, but many orthodontists prefer a planned treatment of both the orthodontia and the surgical orthognathic correction.

An area of controversy is whether or not a split palate (sagittal fracture of the maxilla) should be fixated. It is the opinion of many surgeons that these fractures should be stabilized either by open reduction with fixation of the hard palate or by the use of a palatal splint both to provide for adequate reduction in terms of narrowing the palate and maxillary dental arch and to prevent sagittal rotation of the fracture. The latter is felt to be the cause of oral-nasal fistulas that can become evident after such fractures.

Dental injuries may occur in both maxillary and mandibular fractures. Some require urgent care to save the teeth, whereas others require early intervention with endodontic surgery. Finally, prosthetics restoration is commonly required, entailing bone grafting of avulsed alveolar segments to provide an adequate dental alveolus either for a tissue-borne denture or for placement of osseointegrated implants for an implant-borne prosthetic device.

The most common complication with zygomatic complex fractures is malposition. Prior to the use of internal plate fixation, the most common zygomatic deformity was flattening of the malar eminence secondary to inward and inferior rotation of the zygoma. Commonly associated with this was the prolapse of the orbital floor leading to increased orbital volume often with hypophthalmos and enophthalmos. Because plate fixation has become more popular, an additional deformity seen is that of outward rotation of the zygomatic complex manifested by a lateral overprojection of the zygomatic arch and body that also changes with increased orbital volume in the globe position. These orbitozygomatic deformities are corrected generally by osteotomies and secondary orbital reconstructions.

Other common complications of orbital and zygomatic fracture repairs include palpation of the plates when they are placed over the orbital rim, and the use of too large a plate. Permanent numbness of the cheek (although rare) and the restriction of the globe due to injury of the extraocular muscles or injury to their nerve supply may occur. A feared complication of orbital fracture repair is visual loss, whether temporary or permanent. Patients who undergo periorbital fracture surgery should be observed for at least 24 hours and have frequent visual checks. It has been stated that a patient can have up to 90 minutes of retinal artery occlusion before the visual losses are irreversible. Accordingly, visual checks should be performed as soon as possible on all patients undergoing zygomatic or orbital surgery.

The most common complication with nasoethmoid fractures repair is persistent telecanthus. Prevention has been described, but it remains a common postoperative problem. It presents an extremely difficult posttraumatic problem for correction, and an ethmoidectomy is often useful in providing a space to allow for adequate overcorrection of the medial canthus. These repairs are fraught with problems and they yield unsatisfactory results.

With frontal sinus fracture repairs, the most common problem is irregularities over the frontal bone. In very comminuted anterior table fractures there tends to be resorption of small fragments even when semirigidly fixated. The use of titanium mesh and, more recently, hydroxyapatite cement has been helpful in preventing such contour deformities. Frontal bone contour deformities can occur after fractures to this region and operative approaches when craniotomies have been performed. Most of these deformities are limited in extent but some deformities are quite significant. These can be repaired via a coronal approach using a variety of implant materials such as methylmethacrylate, titanium mesh, or other newer materials such as hydroxyapatite cement.

The other dreaded complication of frontal sinus fracture repair is either acute or subacute infection of the region, representative of a blocked nasofrontal duct. This can also occur when obliteration has been performed. The etiology is probably either inadequate obliteration of the nasofrontal duct or inadequate removal of mucosa from the frontal sinus itself. This secondary infective process is generally of a chronic nature and it is treated with traditional chronic frontal sinusitis surgery techniques. However, endoscopic approaches are gaining in popularity with mixed results.

Finally, complications of panfacial fractures can be any combination of those problems described in the individual fracture regions. Additionally, as stated earlier, the soft tissue deformities become increasingly common with a greater number of surgical approaches. Accordingly, adequate suspension of midfacial, lower eyelid, and temporal soft tissues is of extreme importance.

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RHINOPLASTY

Dean M. Toriumi

Rhinoplasty is a complex operation that requires the surgeon to account for variances in anatomy, facial aesthetics, tissue healing, and the long-term effects of scar contracture. Surgeons who follow their patients long term will be able to assimilate valuable experience that can be used to help determine the surgical techniques that will be most successful in patients with any given anatomic deformity. Precise record keeping, noting exactly what was done at surgery, allows the surgeon to go back and correlate a successful outcome with a particular technique or a poor outcome with a less reliable technique. Successful rhinoplasty is all about analyzing the patient's primary deformities, knowing what the underlying anatomy will likely be, and choosing a specific technique that will give the patient the best chance for a good, long-term outcome. The surgeon must be able to execute the operation properly, minimize tissue trauma, and provide appropriate postoperative care. One of the most complex aspects of rhinoplasty is determining how the effects of scar contracture will effect healing of the nose, which requires a high level of experience and judgment. The philosophy of most rhinoplasty surgeons is moving away from excision of tissue and toward repositioning or stabilizing the existing structures.¹⁻³ Patients with good structural support tend to heal more favorably and are better able to withstand the forces of scar contracture over time.

ANATOMY

The nose can be divided into three anatomic regions: the upper, middle, and lower third. The upper third is composed primarily of the nasal bones and overlying skin, the middle third is composed of the upper lateral cartilages and septum, and the lower third is composed primarily of the lower lateral cartilages and nasal septum. The skin covering the nose varies in thickness, with the skin of the nasion and tip being relatively thick. There is thinner skin over the nasal bones and middle vault. The nasal bones tend to be relatively thin and are connected via a suture line to the thicker bone of the nasal process of the frontal bone and ascending process of the maxilla.⁴

The nasal bones tend to be thinnest at the antero-caudal margin where they meet the upper lateral cartilages. The upper lateral cartilages overlap the caudal aspect of the nasal bones and connect to the undersurface of the nasal bones. This overlap of cartilage and bone is critical to the support of the middle vault, and disruption of this connection can result in deformity or collapse of the upper lateral cartilages.

In the middle nasal vault, the upper lateral cartilages come up to meet the dorsal aspect of the nasal septum and form a T shape or Y configuration on cross section.⁵ This T shape creates a horizontal component to the middle vault that accounts for the trapezoidal shape and much of the width of the middle third of the nose (Fig. 5-1). Patients with an excessively wide middle nasal vault tend to have a broader horizontal component to the middle third. On the other hand, patients with a narrow nose tend to have more of a triangular shape to the middle vault, and the upper lateral cartilage has little or no horizontal component as it meets the dorsal septum. Asymmetry of the dorsal aspect of the nasal septum may result in asymmetry of the upper lateral cartilages as they meet the deviated dorsal septum. This may create a deviated appearance to the middle third of the nose. Patients with short nasal bones, long upper lateral cartilages, and a projecting nose are at increased risk for collapse of the middle vault. Simple palpation of the nasal bone length can help predict patients who will be at higher risk of postoperative middle vault collapse. Sheen and Sheen³ referred to these patients as those with the "narrow nose syndrome." When dorsal hump reduction is performed, there may be loss of medial support, and the upper lateral cartilages can collapse inferomedially (Fig. 5-2).⁵ On the other hand, patients with long nasal bones and short upper lateral cartilages rarely have problems with middle vault collapse because the upper laterals are well supported. Spreader grafts can be used to reconstruct the middle vault in patients who have short nasal bones.

The integrity of the support mechanisms of the nose is critical to the preservation of favorable nasal tip contour. The major support mechanisms of the nose include the inherent strength and integrity of the lower lateral cartilages, the attachment of the upper lateral cartilages

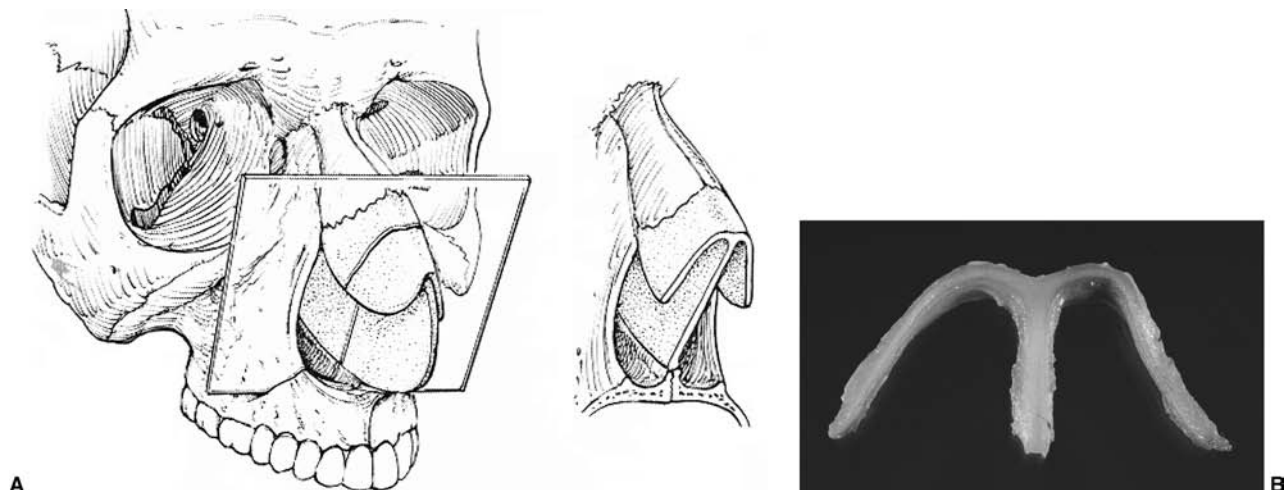


FIGURE 5-1 (A) Cross section taken through the middle vault near the osseocartilaginous junction. The trapezoidal shape of the middle nasal vault is partly due to the horizontal or T-shaped component of the upper lateral cartilages as they meet the dorsal margin of the nasal septum. (B) Cross section of a fresh cadaver specimen that demonstrates a prominent horizontal component to the middle nasal vault. (From Toriumi DM. Management of the middle nasal vault. *Op Tech Plast Reconst Surg* 1995;2;16–30, with permission.)

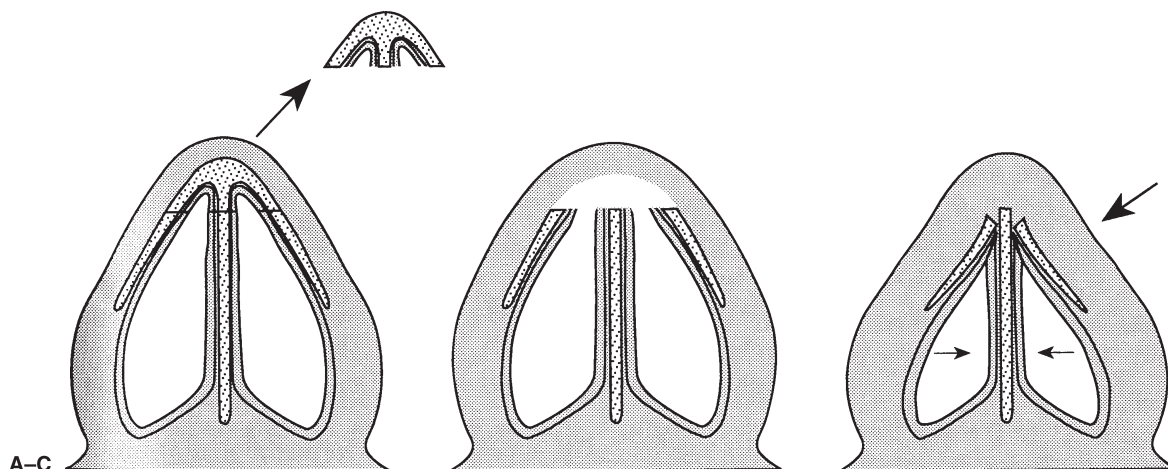


FIGURE 5-2 (A) Dorsal hump is removed with some intranasal mucosa. (B) The medial support of the upper lateral cartilages is excised. (C) After dorsal hump removal in patients with short nasal bones, the long flail upper lateral cartilages can collapse inferomedially because of lack of medial support.

to the lower lateral cartilages (scroll or recurvature), and the fibrous attachment between the feet of the medial crura and the caudal septum.⁴ The septal cartilage should also be considered a major support mechanism of the nose as it is critical to supporting the lower two thirds of the nose. Minor support mechanisms include the interdomal ligament, nasal spine, and attachments of the lower lateral cartilages to the overlying skin and soft tissue. The surgeon should attempt to preserve these support mechanisms or strengthen them to preserve favorable nasal contour. The caudal aspect of the septum and its relationship to the nasal tip cartilages is also critical to nasal tip support and contour.

The lower lateral cartilages typically consist of three different components: the conjoined medial crura, the lateral crura, and the divergent intermediate or middle crura. The medial crura parallel each other and the intermediate crura diverge to meet the domes and lateral crura, which lie in a more horizontal plane. The divergent intermediate crura correspond to the favorable curvature of the columellar-lobular angle (Fig. 5-3). Obliteration of this divergence can result in blunting of the columellar-lobular angle. In many patients, there is a notch near the junction of the intermediate and lateral crura. This notch frequently corresponds to the overlying soft tissue triangle or facets. Patients with prominent notches frequently



FIGURE 5-3 The lower lateral cartilages consist of the medial crura, intermediate crura, and lateral crura. The intermediate crura diverge to meet the lateral crura, which lie in a more horizontal plane and form the columellar/lobular angle. Obliteration of this divergence can blunt the columellar/lobular angle. (A) Basal view showing divergent intermediate crura. (B) Lateral view showing subtle curvature of the columellar/lobular angle as the medial crura meet the intermediate crura.

have prominent facets. The lateral crura typically project laterally toward the pyriform aperture and the sesamoid cartilages. In some patients, the lateral crura take on a more cephalic orientation as the cartilages follow the middle nasal vault instead of passing toward the pyriform aperture (Fig. 5-4). Patients with cephalic positioning of the lateral crura are at high risk for lateral wall weakness and external nasal valve collapse because there is insufficient lateral wall support. Treatment requires the addition of support to the lateral wall in the form of alar batten grafts or equivalent lateral wall grafts.

ANALYSIS AND DIAGNOSIS

Precise nasal analysis and diagnosis of variant nasal anatomy is critical to success in rhinoplasty surgery. Surgeons choose surgical techniques based on the patient's preoperative deformities and then determine the most effective technique for correction of the deformity. When performing nasal analysis, the surgeon

should be able to define the external nasal deformities and predict the underlying nasal anatomy. This provides the most helpful information for determining the appropriate surgical technique.

We begin our analysis by assessing the surrounding facial features and determining whether or not the nose is in balance with the rest of the face. The nose should be approximately one-third the length of the face and one-fifth the horizontal width. The surgeon should assess the projection of the chin and configuration of the forehead. Good chin projection will better balance with a well-projected nose, whereas a retrognathic chin will give the illusion of an overprojected nose despite normal projection. When operating on an overprojected nose, patients with an underprojected chin can benefit from increasing chin projection to better balance the nose. This relationship is particularly important in patients with thick skin and an overprojected nose, as thick skin does not redrape properly if the nose is made much smaller.

Creating a good relationship between the nose, forehead, and glabella allows a defined nasal starting point



FIGURE 5-4 (A) Lateral crura typically move laterally toward the pyriform aperture. (B) Cephalically positioned lateral crura. Note how the lateral crura follow the middle nasal vault in a more cephalic orientation.

and good facial balance. Patients with a flat forehead and glabella tend to lack a defined nasal starting point, making the nose look overly long. One should avoid augmenting the radix in patients with a flat forehead and a relatively flat glabella. In the female, the nasal starting point should be at the level of the superior palpebral fold with the eyes in forward gaze. The nasal starting point can be slightly higher in male patients.

Nasal tip projection can be analyzed in many different ways. The Goode⁶ method of determining tip projection sets ideal tip projection at 0.55 of the distance from the nasion to the tip-defining points. In another method, Crumley and Lanser⁷ set ideal tip projection as a relationship to a vertical line dropped from the nasion to the nasal base. Byrd and Hobar⁸ look at many nasal parameters as a relationship to several relatively uniform facial measurements. After assessing tip projection with these methods, surgeons should use their aesthetic sense to determine what would be an appropriate tip projection. Surgeons should balance the nose with the chin projection and forehead configuration. Noses with adequate projection tend to look better and more refined on frontal view. Decreasing nasal projection will decrease lateral wall shadowing and tend to create a flatter, less defined look on frontal view. It is critical to focus on enhancing the frontal view, as this is the most important view.

PREOPERATIVE CONSIDERATIONS

Preoperative photography of the patient should be attained prior to performing aesthetic and functional rhinoplasty. Standard rhinoplasty views include the frontal, right and left lateral, right and left oblique, and basal views. Photographs should be taken using standard lighting and standard magnification and reproducible positioning of the head to allow precise comparison from pre- to postoperative states. Harsh or uneven lighting is the most common flaw in patient photography. Nonuniform lighting tends to create unwanted shadows and poor representation of true facial contours. We prefer to use a neutral background color such as light blue to enhance skin tones.

When planning cosmetic rhinoplasty, we recommend doing computer imaging to demonstrate to the patient the realistic changes that can be performed with good reliability. The imaging can educate the patient on why the nose may need to be made larger with dorsal augmentation or radix augmentation to improve nasal balance and maximize the look on the frontal view. These changes are particularly important in patients with thicker skin and those who have undergone previous surgery. When performing imaging it is critical to image in a fashion that portrays realistic expectations to the patient. Some patients have significant limitations in

their soft tissues or support structures that will allow only a modest degree of improvement. When imaging patients with such limitations, it is imperative that the surgeon show representative images to avoid unrealistic expectations. We prefer to underimage and show the patient a proposed outcome that we believe we can achieve with a high level of confidence.

Nasal analysis performed on the frontal view should assess nasal symmetry and length; the width of the upper, middle, and lower thirds of the nose; tip contour; width of the alar base; prominence of the infratip lobule; and alar flare. The surgeon should assess the continuity of the brow-tip aesthetic line and determine if it is unbroken as it passes from the medial brow to the lateral wall of the nose to the tip-defining points. Ideally, the female nose should be slightly wider at the radix, narrow slightly at the middle third, and then be slightly wider at the nasal tip (Fig. 5-5).

On lateral view, the radix corresponds to the soft tissue depths of the nasofrontal angle. The surgeon should assess the radix to determine if it is overly deep or shallow. An overly deep radix gives the nose a shorter appearance with a dorsal hump (Fig. 5-6). A shallow radix gives the appearance of a longer nose with a poorly defined nasal starting point. Evaluation of the lateral view should also assess the presence of a dorsal hump, tip/supratip relationship, tip projection, lobule configuration, alar/columellar relationship, nasolabial angle, and nasal length.

Analysis of the basal view should reveal symmetry of the nasal base, the infratip lobule/columella relationship,



FIGURE 5-5 Female nose on frontal view showing slight width in the radix with narrowing in the middle vault and slight widening in the lower nasal tip. This subtle hourglass appearance is ideal in the female patient.



FIGURE 5-6 Patient with a deep radix that gives the nose a shorter appearance with a more pronounced dorsal hump. Elevation of the radix with conservative hump reduction would be ideal in this patient.

tip width, alar flare, width of the nasal base, and tip projection. The surgeon should also identify deviations of the caudal septum, flaring medial crural footplates, or internal recurvature of the lateral crura.

Preoperative diagnosis of factors contributing to nasal obstruction is critical to provide maximal functional results as well as a favorable aesthetic result. The surgeon should perform a thorough intranasal examination including an endoscopic exam in patients with nasal symptoms. Anterior rhinoscopy should be performed before and after nasal decongestion with a vasoconstrictive agent. The entire septum should be examined; the size of the turbinates should be assessed, and the presence of nasal polyps and the status of the internal and external nasal valve should be noted.

NASAL SEPTUM

Procedures typically performed to improve nasal function include septoplasty, nasal valve surgery, and turbinoplasty. Septoplasty is usually performed to correct deviations in the bony or cartilaginous septum, or to harvest septal cartilage for grafting purposes. Septoplasty can be performed via several different approaches. The different approaches include the Killian, hemitransfixion, full transfixion, or external rhinoplasty. Selection of the approach to the nasal septum depends on the goals of the surgery. A Killian incision is made cephalic to the caudal margin of the septum and is made on one side of the septum. The hemitransfixion incision can be used when the surgeon must correct a deviation or modify the

caudal aspect of the nasal septum. This incision is made at the caudal aspect of the septum and goes through the mucosal flap on only one side of the septum. The full-transfixion incision is made through the mucosal flaps on both sides of the caudal aspect of the septum. This incision results in significant loss of support if extended down to the base of the medial crural footplates, and is one method for decreasing projection in the overprojected nasal tip. The external rhinoplasty approach to the nasal septum can be used in cases requiring alteration of the caudal margin of the septum. In this case, once the lower lateral cartilages are dissected, the medial crura are dissected apart and the caudal septum is identified. The mucoperichondrial flaps can then be dissected, and both sides of the septal cartilage can be completely exposed. If additional exposure is required, the upper lateral cartilages can be freed from the septum to gain maximal exposure of the entire cartilaginous septum. This approach is ideal for correcting severe caudal septal deviations (Fig. 5-7).

Once exposure of the septum is achieved, deviated portions of the septum can be excised, leaving an intact L-shaped septal strut consisting of at least 1.5 cm of septal cartilage both caudally and dorsally. The surgeon should keep a stable connection between the dorsal cartilaginous septum and the bony septum (ethmoid plate) to avoid loss of support in the middle nasal vault. Septal support can also be maximized by leaving a fibrous connection between the inferior aspect of the caudal aspect of the septum to the nasal spine and maxillary crest. In some cases, correction of deviations of the caudal septum can be corrected by freeing the caudal septum from the nasal spine and maxillary crest, trimming excess cartilage, and resuturing the caudal septum to the periosteum about the nasal spine and maxillary crest. In many cases, the concave side of the deviation may require light cross-hatching to eliminate memory of the cartilage and allow

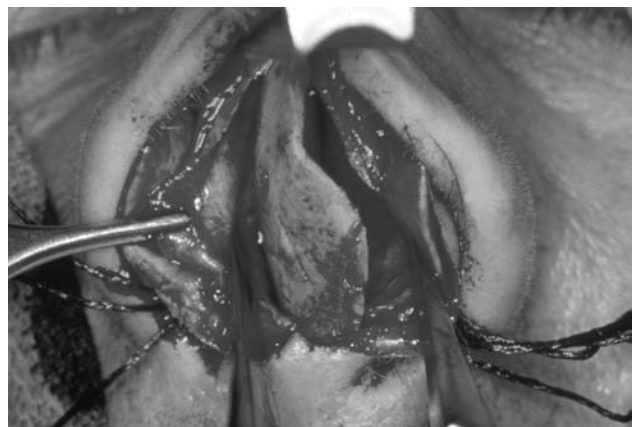


FIGURE 5-7 Exposure of a severe caudal septal deviation via the external rhinoplasty approach after dissecting between the medial crura and freeing the upper lateral cartilages from the dorsal margin of the septum.

straightening. In some cases, the maxillary crest itself is deviated, obstructing the airway. In these cases, the obstructing portion of the maxillary crest can be trimmed or burred down with a rotating power burr.

INCISIONS AND APPROACHES TO THE NOSE

Rhinoplasty can be performed using one of four basic approaches. These approaches require the use of a marginal, intercartilaginous, intracartilaginous, or transcolumellar incision (Fig. 5–8). Endonasal approaches include nondelivery approaches and delivery approaches. Nondelivery approaches include the cartilage-splitting approach and retrograde technique. These techniques are ideal for patients requiring minimal changes to nasal tip contour using conservative excisional techniques. In the cartilage-splitting approach, an intracartilaginous incision is made through the vestibular mucosa and underlying cephalic margin of the lateral crura to achieve a conservative volume reduction of the lateral crura (Fig. 5–9). When performing this approach it is critical to recognize the anatomy of the lateral crura to execute precise and conservative volume reduction. In the retrograde

approach, an intercartilaginous incision is made and the vestibular mucosa is dissected caudally to expose the cephalic margin of the lateral crura, which can then be trimmed. The intercartilaginous incision also provides access to the nasal dorsum (Fig. 5–10). In this approach, the cephalic margin of the lateral crura can be visualized and then precisely trimmed. In both of these approaches, the lateral crura are left attached to the overlying soft tissue, limiting dissection of the lower lateral cartilages. These approaches are good for patients who require minimal volume reduction of the lateral crura and do not require alteration of the domal angle of the lower lateral cartilages. These patients typically have a symmetric nasal base contour, which approximates an equilateral triangle. Patients with an obtuse domal angle and trapezoidal shape on base view require a delivery approach or external rhinoplasty approach to change the shape of the nasal base.

The delivery approach involves creation of bilateral chondrocutaneous flaps using marginal and intercartilaginous incisions. The marginal incision is made along the caudal margin of the lateral crura, and the intercartilaginous incision is made between the cephalic margin of the lateral crura and the caudal margin of the upper lateral cartilage (Fig. 5–11). While making the intercartilaginous incisions, the knife can be used to elevate the soft tissues of the middle nasal vault. Once these incisions are made, the lower lateral cartilage are dissected away from the overlying skin and soft tissue, and the lateral crura can be delivered into the field using a blunt, flat instrument (Fig. 5–12). Good exposure of the domes can be achieved with this approach, allowing placement of dome sutures or other tip work. In some cases the intercartilaginous incision may need to be extended to follow the caudal margin of the septum to gain additional exposure.

The external rhinoplasty approach requires the use of an inverted-V midcolumellar incision and bilateral marginal incisions (Fig. 5–13). The midcolumellar incision should be made midway between the top of the nostril and the base of the nose. It is better to err in making the incision lower as opposed to too high on the columella, as higher incisions are more likely to be visible on the frontal view. If there is significant flaring of the medial crural footplates, the columellar incision may impinge on this area. If this is the case, the incision will be easier to close if the footplates are conservatively approximated. The marginal incisions are made at the caudal margin of the lateral crura (Fig. 5–14). The columellar extension of the marginal incision is made just caudal to the caudal margin of the medial crura to avoid damaging the medial crura (Fig. 5–15). Converse scissors can be advanced under the columellar flap, taking great care not to damage the medial crura (Fig. 5–16). Special care should be taken not to bevel the columellar incision, as this will make it more difficult to close at the end of the operation. The columellar flap is elevated in the submuscular plane,

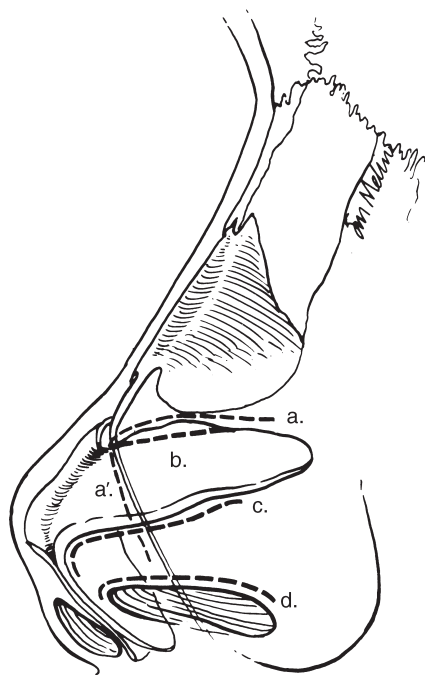


FIGURE 5–8 Incisions used in rhinoplasty. Shown are the intercartilaginous incision (retrograde and delivery approach), intracartilaginous incision (cartilage-splitting approach), marginal incision (delivery and external approach), and the transcolumellar incision (external approach). a, intercartilaginous; a', transfixion extension of intercartilaginous incision; b, intracartilaginous incision (cartilage-splitting incision); c, marginal incision; d, rim incision. It is very rare that a rim incision is ever made, as it tends to deform the alar rim.

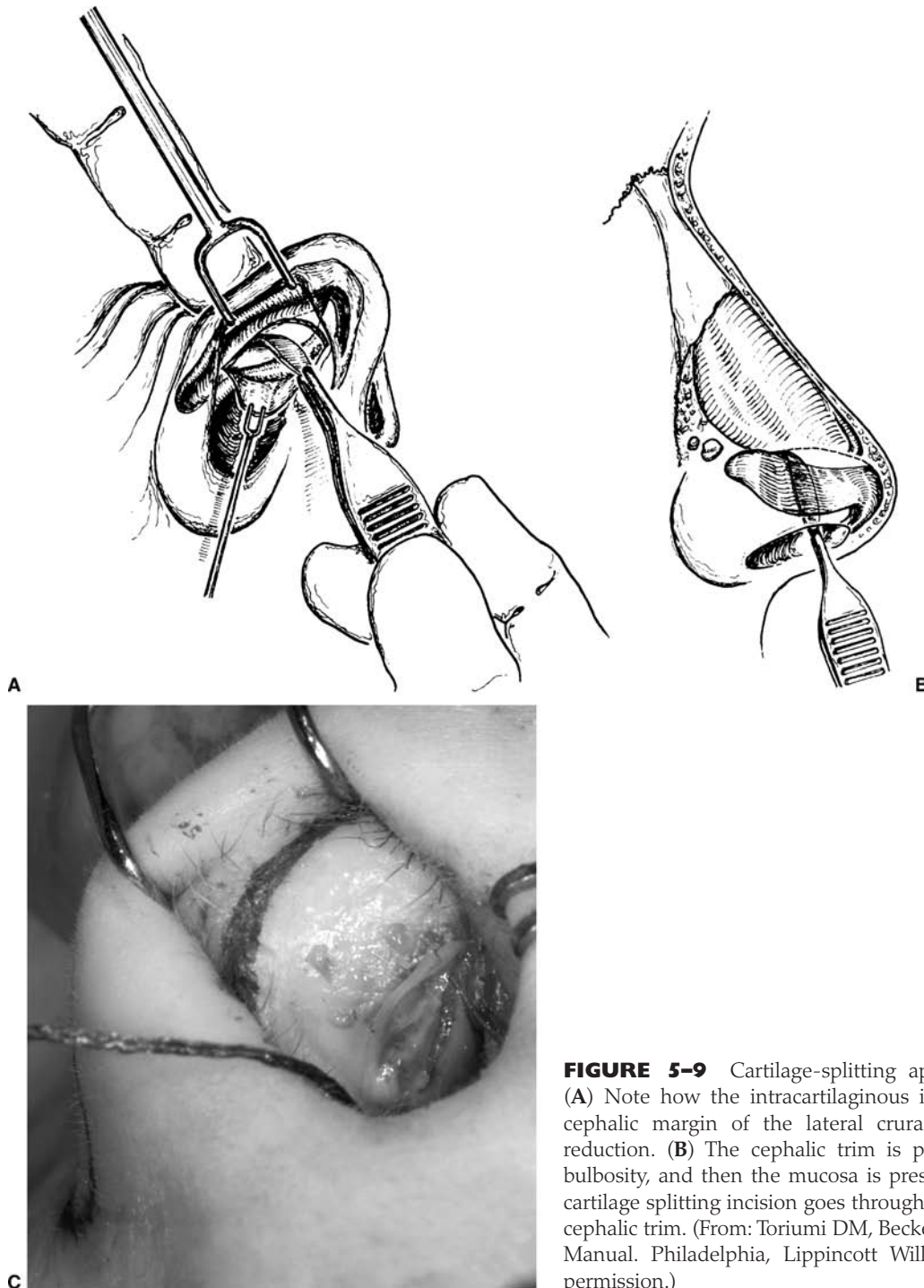


FIGURE 5-9 Cartilage-splitting approach to the lateral crura. (A) Note how the intracartilaginous incision is made close to the cephalic margin of the lateral crura to avoid excessive volume reduction. (B) The cephalic trim is performed, decreasing the tip bulbosity, and then the mucosa is preserved and resutured. (C) The cartilage splitting incision goes through the cartilage at the site of the cephalic trim. (From: Toriumi DM, Becker DG: *Rhinoplasty Dissection Manual*. Philadelphia, Lippincott Williams & Wilkins, 1999, with permission.)

leaving the subcutaneous tissues attached to the under-surface of the flap. Three-point countertraction can be used to help dissect the domes and lateral crura (Fig. 5-17). Dissection over the lateral crura should be performed in the submuscular plane immediately adjacent to the surface of the lateral crura (Fig. 5-18). Dissection over the middle vault should also be submuscular to avoid excessive bleeding. Elevation of this flap provides maximal exposure of the lower lateral cartilages

and middle nasal vault. A Joseph periosteal elevator is used to elevate the periosteum off of the nasal bones to avoid damaging the thin dorsal skin. Leaving the periosteum on the nasal bones will decrease the thickness of the dorsal skin and can result in atrophic changes (telangiectasia, etc.) and inadequate dorsal camouflage. Skin flap elevation should be just sufficient to allow the necessary surgical maneuvers to accomplish the proposed contour changes. If the surgeon plans on performing dorsal

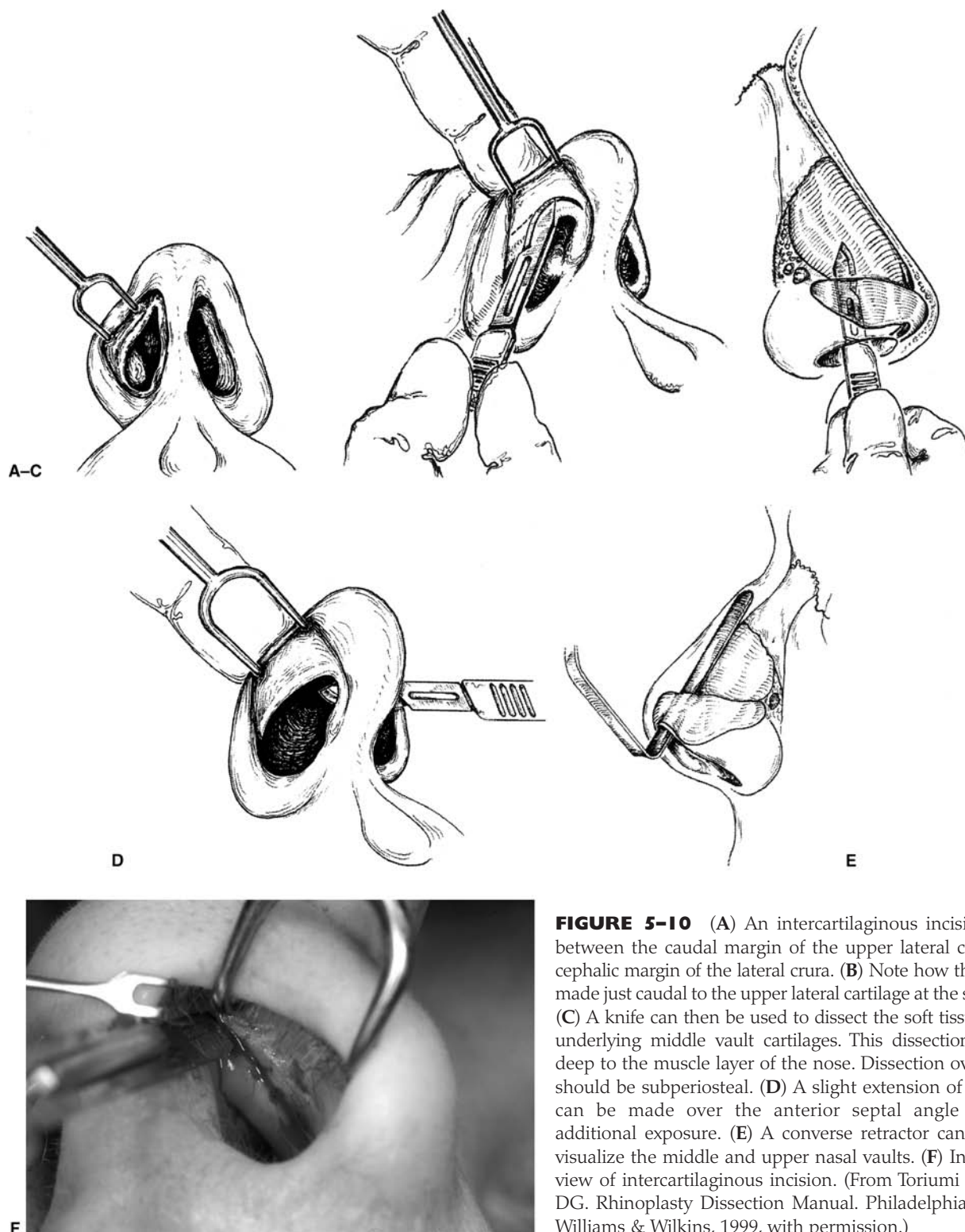


FIGURE 5-10 (A) An intercartilaginous incision is made between the caudal margin of the upper lateral cartilage and cephalic margin of the lateral crura. (B) Note how the incision is made just caudal to the upper lateral cartilage at the scroll region. (C) A knife can then be used to dissect the soft tissue off of the underlying middle vault cartilages. This dissection should be deep to the muscle layer of the nose. Dissection over the bone should be subperiosteal. (D) A slight extension of the incision can be made over the anterior septal angle to provide additional exposure. (E) A converse retractor can be used to visualize the middle and upper nasal vaults. (F) Intraoperative view of intercartilaginous incision. (From Toriumi DM, Becker DG. *Rhinoplasty Dissection Manual*. Philadelphia: Lippincott Williams & Wilkins, 1999, with permission.)

augmentation or radix augmentation, we recommend leaving a narrow pocket over the dorsum or radix.

Once surgical maneuvers are performed, special attention should be paid to the closure of the mid-columnellar incision to maximize scar camouflage. We use

a single midline subcutaneous 6-0 PDS (polydioxanone, Ethicon, Somerville, NJ) suture to take tension off of the skin closure. Then we maximize skin edge eversion using 7-0 nylon vertical mattress sutures. We typically remove these sutures on the seventh postoperative day.

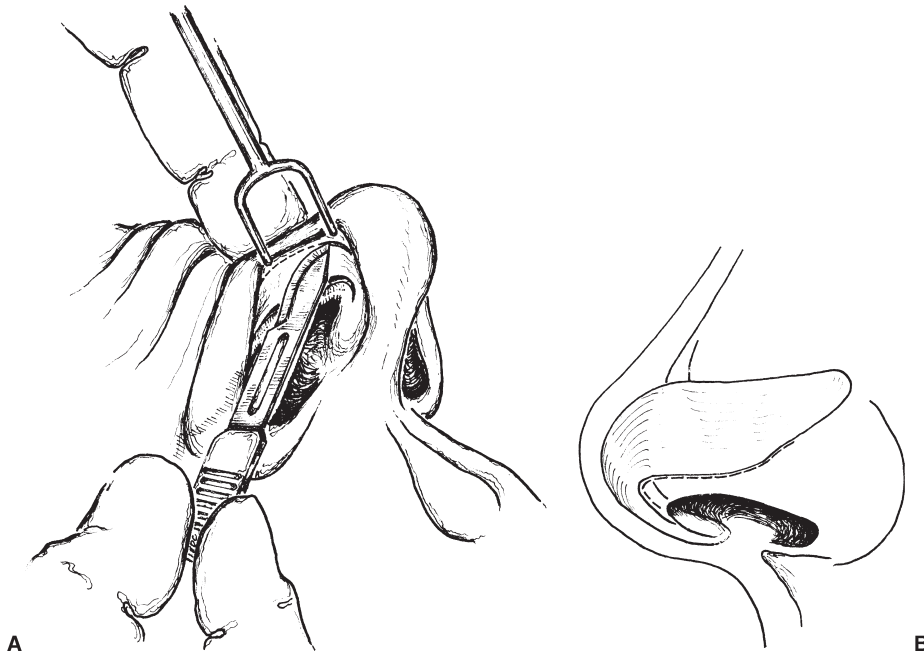


FIGURE 5-11 Delivery approach. (A) Execution of the marginal incision. (B) Note how the incision is made at the caudal margin of the medial and lateral crus.

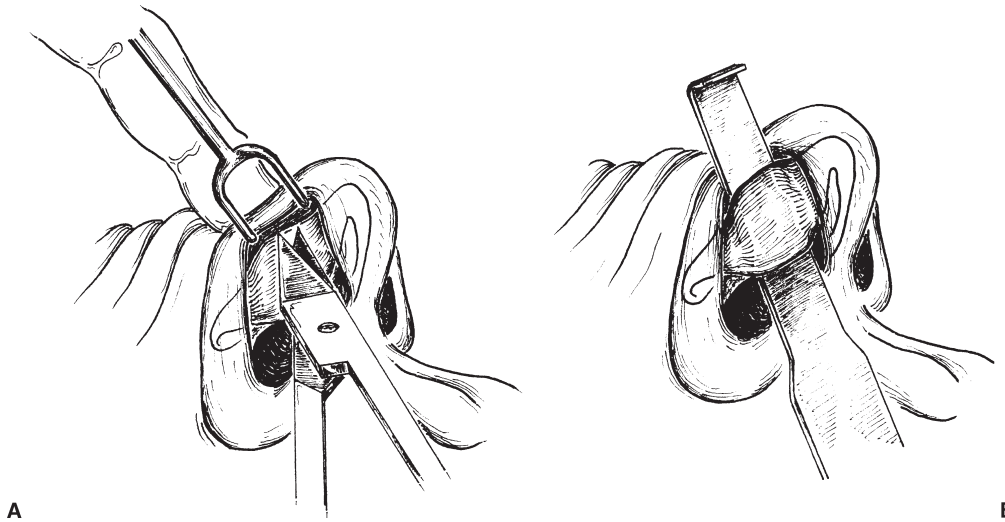


FIGURE 5-12 Delivery approach. (A) Scissors can be used to dissect the soft tissue from the surface of the lateral crura. (B) The lower lateral cartilages can then be delivered into the field allowing good exposure of the lateral crura and domes. (From Toriumi DM, Becker DG, *Rhinoplasty Dissection Manual*. Philadelphia: Lippincott Williams & Wilkins, 1999, with permission.)

There may be increased tip edema associated with the external rhinoplasty approach. However, we have found that dissection in the submuscular plane minimizes bleeding and preserves the venous and lymphatic outflow to the skin flap and can minimize edema.

PROFILE ALIGNMENT

After the structures of the nose are exposed and assessed, the surgeon can determine the plan for profile

alignment. If the patient has a dorsal convexity, it may be prudent to reduce the dorsum. The objective is to leave the dorsum as high as possible yet allow sufficient reduction to create a favorable tip/supratip and dorsum-to-radix relationship. There is a tendency to overreduce the bony dorsum, leaving the patient with inadequate dorsal height. It is preferable to preserve a high dorsal profile, as this will make the nose appear more refined on frontal view. If the patient has a dorsal hump and the radix is low, a radix graft can be placed into a tight pocket



FIGURE 5-13 Inverted-V midcolumellar incision made midway between the top of the nostrils and the base of the nose. Special care should be taken not to make this incision too high on the columella, otherwise it may be visible on the frontal view.



FIGURE 5-16 Angled converse scissors are advanced under the columellar flap, taking care to remain caudal to the medial crura. Special care is taken to avoid damaging the caudal margin of the medial crura.



FIGURE 5-14 The marginal incisions are made along the caudal margin of the lateral crura. The caudal margin of the lateral crura can be palpated to help locate this incision.



FIGURE 5-17 Three-point countertraction using three double-prong hooks helps deliver the domes into the field. The retraction is controlled with the small two-prong hook that is applied to the undersurface of the dome providing traction toward the surgeon. Converse scissors are used to dissect from medial to lateral, directing the dissection toward the marginal incision.



FIGURE 5-15 The marginal extension of the columellar incision is made just caudal to the medial crura. In some patients the medial crura protrude caudally and are easily damaged.

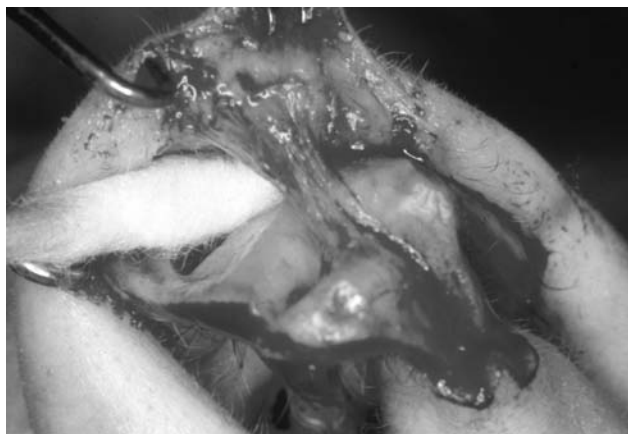


FIGURE 5-18 Dissection over the lateral crura is performed deep to the muscle and immediately adjacent to the cartilage surface. Blunt dissection can be used if the dissection is performed in the proper tissue plane.



FIGURE 5-19 When the radix is low in a patient with a dorsal hump, a radix graft can be placed into a tight pocket over the nasofrontal angle to elevate the radix to a level that will align with a modest reduction of the dorsal hump. (A) Normal radix with acceptable transition from glabella to nasal dorsum. (B) Deep radix with prominent dorsal hump. Note how the radix graft elevates the nasofrontal angle and creates a more acceptable transition from glabella to dorsum (broken line). (C) Note how the radix graft fills the deep nasofrontal angle and camouflages the dorsal hump.



over the nasofrontal angle to create a straighter profile while leaving the dorsum higher (Fig. 5-19). The graft should be placed into a narrow subperiosteal tunnel over the nasofrontal angle (Fig. 5-20). Typically, these are smaller, lightly crushed cartilage grafts that are less likely to be palpable or visible. We usually place radix grafts at the end of the operation to minimize the chance of displacement. When planning to raise the radix with a graft, the dorsal hump reduction should be more conservative.

Dorsal hump reduction can be performed using sharp dissection for the cartilaginous vault and osteotomes or rasps for the bony dorsum. When larger dorsal humps are to be excised, an extramucosal dissection can be

performed to free the mucosa from the undersurface of the upper lateral cartilages and dorsal septum. Then when a large dorsal hump is excised, the underlying mucosa will not be violated. Once the cartilaginous dorsal hump is incised with a No. 15 blade, it can be left attached to the bony dorsum and used as an insertion point for a Rubin osteotome (Fig. 5-21). We prefer to use a sharp Rubin osteotome; however, several different osteotomes can effectively reduce the bony hump. Special care must be taken to prevent the osteotome from engaging too deeply, resulting in excessive bony hump removal. Once the dorsal hump reduction is completed, a sharp rasp can be used to further refine the bony dorsum and eliminate small dorsal irregularities (Fig. 5-21).

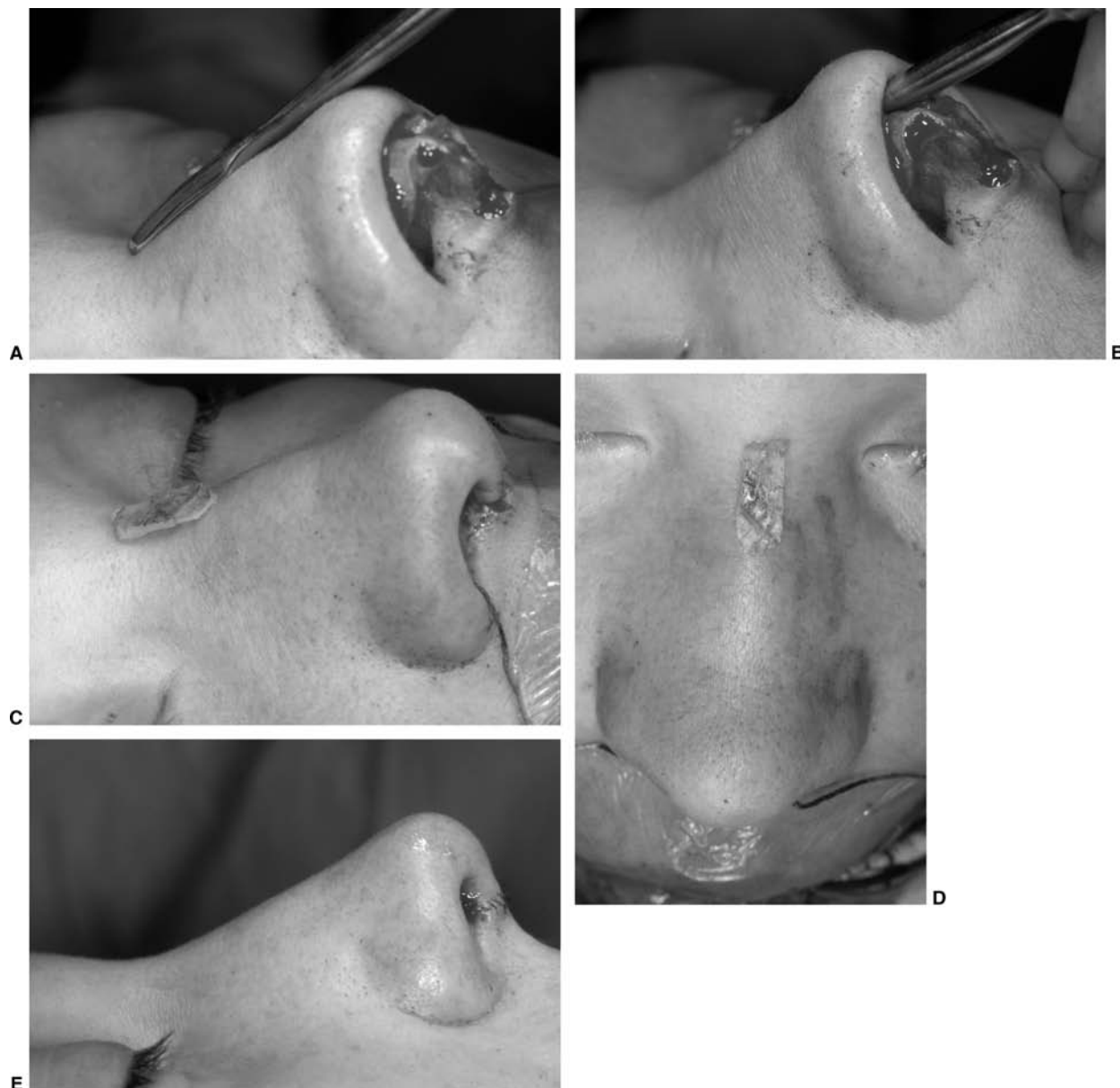


FIGURE 5-20 Placement of a radix graft to efface a deep nasofrontal angle. (A) A Joseph periosteal elevator is used to create a narrow subperiosteal tunnel over the radix. This tight pocket will hold the radix graft in the midline and minimize displacement. (B) The tunnel should not be made too wide or too cephalic. (C) Radix graft over the intended site of implantation. (D) Note how the radix graft is not too wide. (E) Radix graft in position. Note the elevation of the radix and camouflage of the dorsal convexity.

For smaller dorsal humps, a sharp rasp can be used to create a smooth, straight dorsal line. Special care should be taken to avoid avulsing the upper lateral cartilage from its attachment to the undersurface of the caudal margin of the nasal bones. We prefer to use a fine-toothed rasp with no particular pull or push design. This tends to allow better control of bone removal. The rasp should be applied on an oblique angle to minimize trauma to the upper lateral cartilages and avoid avulsion from the undersurface of the nasal bones. Once rasping

is completed the surgeon should irrigate the area with saline solution to remove any bony debris.

There is now a new generation of powered instruments that can be used for profile alignment and reduction of smaller dorsal humps and isolated bony irregularities. These instruments can be used as a power burr or as a power rasp. Power burrs can be used with existing power sinus surgery units and are available in a sheath with winged flanges that protects the burr from the surrounding tissues (Rhinobur, Medtronic-Xomed, Jacksonville, FL).

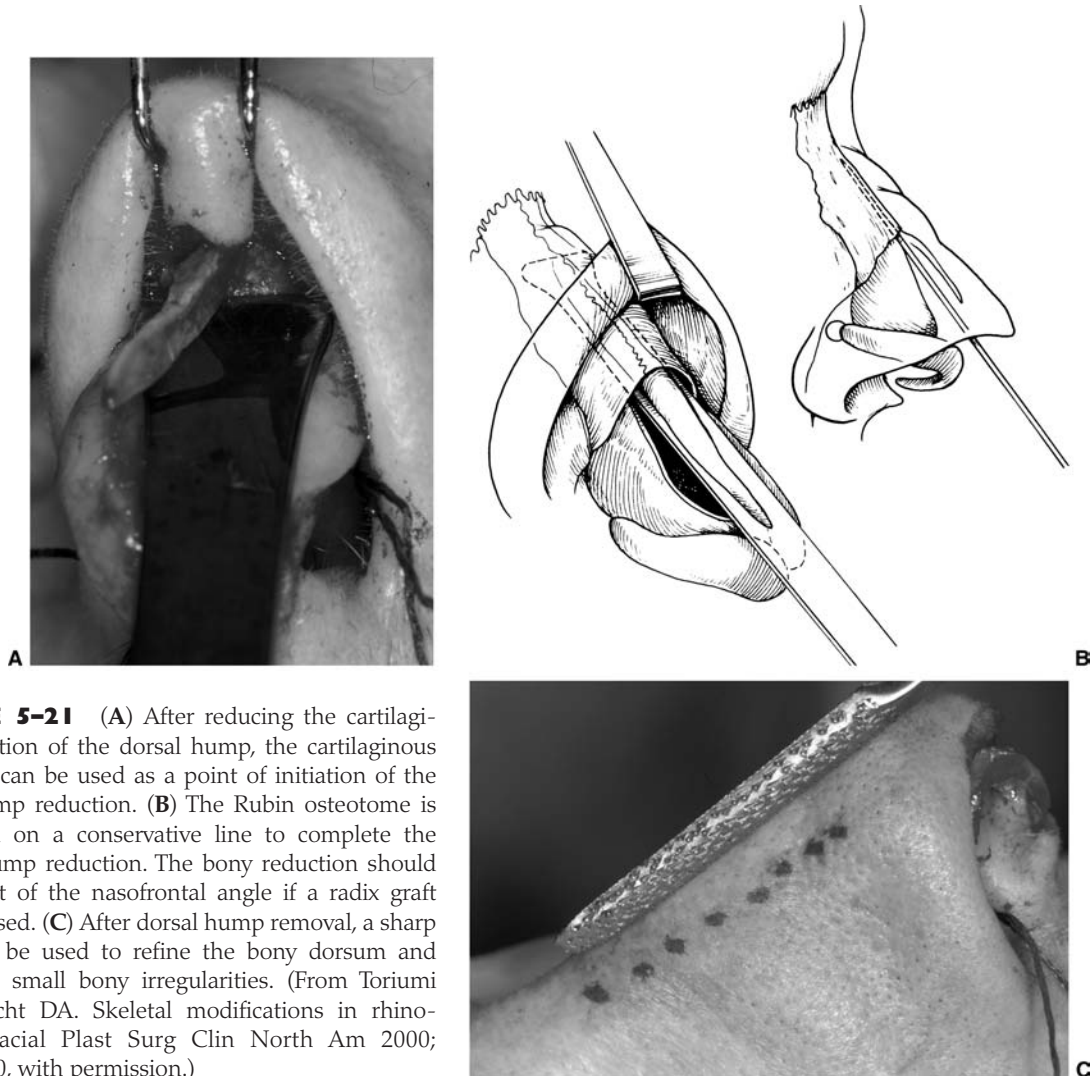


FIGURE 5-21 (A) After reducing the cartilaginous portion of the dorsal hump, the cartilaginous segment can be used as a point of initiation of the bony hump reduction. (B) The Rubin osteotome is advanced on a conservative line to complete the dorsal hump reduction. The bony reduction should end short of the nasofrontal angle if a radix graft is to be used. (C) After dorsal hump removal, a sharp rasp can be used to refine the bony dorsum and eliminate small bony irregularities. (From Toriumi DM, Hecht DA. Skeletal modifications in rhinoplasty. *Facial Plast Surg Clin North Am* 2000; 8:413–430, with permission.)

The power burrs are particularly effective for reduction of small dorsal humps and for smoothing out dorsal irregularities or spurs (Fig. 5-22). The pinpoint control of the burr allows precise bony reduction with minimal surrounding soft tissue damage. The power burr is very effective for correcting isolated bony deformities frequently seen after previous rhinoplasty.

NARROWING THE BONY VAULT

Osteotomies can be performed after dorsal hump reduction or at the end of the operation. We prefer to perform osteotomies prior to middle vault reconstruction in patients with a deviated nose or those who require reconstruction of the middle nasal vault. Performing osteotomies at this time minimizes the incidence of postoperative asymmetries or discrepancies in width between the bony and middle vault. If possible, it is more favorable to perform osteotomies at the end of the operation and may result in less postoperative edema and

bruising. We prefer to use the smallest osteotomes possible to perform adequate bone cuts and narrowing of the bony nasal vault. Both medial and lateral osteotomies can be performed with 2- or 3-mm straight osteotomes. The medial osteotomies are typically performed in a fading fashion beginning in the midline and then fading laterally toward the medial canthus (Fig. 5-23). This path avoids the thicker frontal bone. If the medial osteotomy is driven too far cephalically into the thick frontal bone, the infrafracture of the nasal bone may result in a “rocker deformity” as the nasal bone is separated from the frontal bone at the nasofrontal suture line.

Lateral osteotomies are typically performed with the osteotome passing through the ascending process of the maxilla toward the medial canthus. We prefer high-low-high lateral osteotomies, which pass from high on the pyriform aperture to a lower point on the ascending process of the maxilla and then higher again near the medial canthus (Fig. 5-23). The path of the lateral osteotomy begins by angling the osteotome into the face

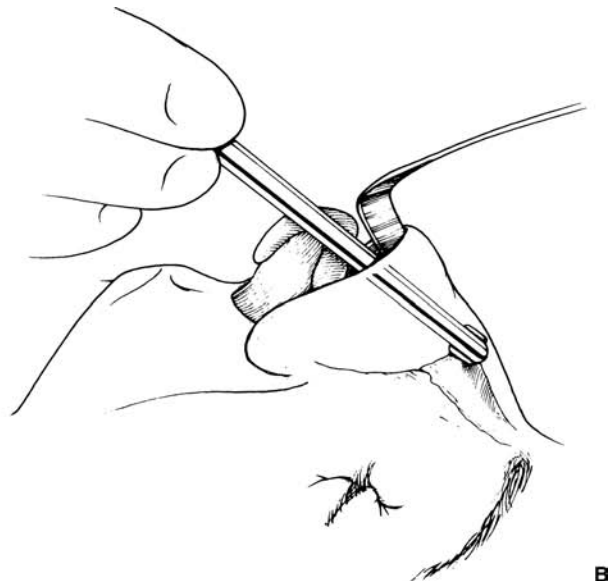


FIGURE 5-22 (A) A power burr can be used to reduce smaller isolated dorsal irregularities that otherwise would be difficult to handle with a rasp. (B) The power burr is applied directly to the bony irregularity protecting the skin from the rotating burr. (From Toriumi DM, Hecht DA. Skeletal modifications in rhinoplasty. *Facial Plast Surg Clin North Am* 2000;8:413–430, with permission.)

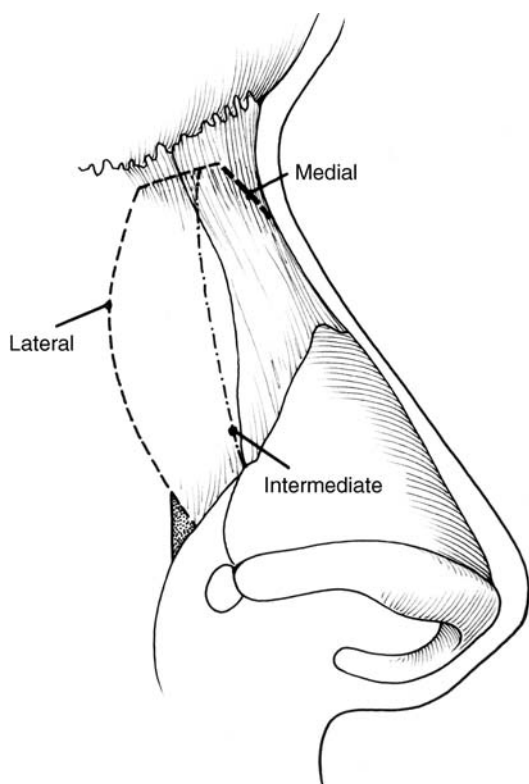


FIGURE 5-23 Medial osteotomies are performed in a fading manner beginning just off the midline of the bony septum and then fading off midline, avoiding the thick frontal bone or the nasofrontal suture line. Lateral osteotomies are performed in a high-low-high path and at the level of the medial canthus. A small triangle of bone is preserved at the base of the pyriform aperture. (From Toriumi DM, Hecht DA. Skeletal modifications in rhinoplasty. *Facial Plast Surg Clin North Am* 2000;8:413–430, with permission.)

3 to 4 mm above the base of the pyriform aperture. The osteotome is advanced along the ascending process of the maxilla and then curved medial to the medial canthus. This path of the lateral osteotomy preserves the position of the inferior turbinate and minimizes functional compromise of the nasal airway after rhinoplasty.⁹ Some surgeons prefer a low to low osteotomy, which can medialize the inferior turbinate in some patients. On rare occasions an intermediate osteotomy is made midway between the medial and lateral osteotomy to correct aberrant nasal bone contour (Fig. 5-23). If a nasal bone is excessively convex, concave, or asymmetric, an intermediate osteotomy can be performed before completing the lateral osteotomy.

Selection of the osteotome is usually based on personal preference, and the surgeon should use the osteotome that most effectively facilitates creating a complete fracture with the least amount of trauma. Smaller osteotomes tend to cause less trauma, resulting in less postoperative edema and ecchymosis. Guarded osteotomes tend to impart greater tissue damage, which may present as increased edema or ecchymosis. Percutaneous (transcutaneous) osteotomies can be used to create precise cuts in the bone and complete the back-fracture site if inadequate medialization of the nasal bones is noted (Fig. 5-24). Without a complete back-fracture, the nasal bones are more apt to migrate back toward their preoperative position. To perform a percutaneous osteotomy and complete the back-fracture, a 2-mm straight osteotome is applied to the point of anticipated back-fracture and advanced with a mallet. Multiple bone perforations are made to weaken the bone and complete the back-fracture. Some surgeons are using percutaneous osteotomies to complete the

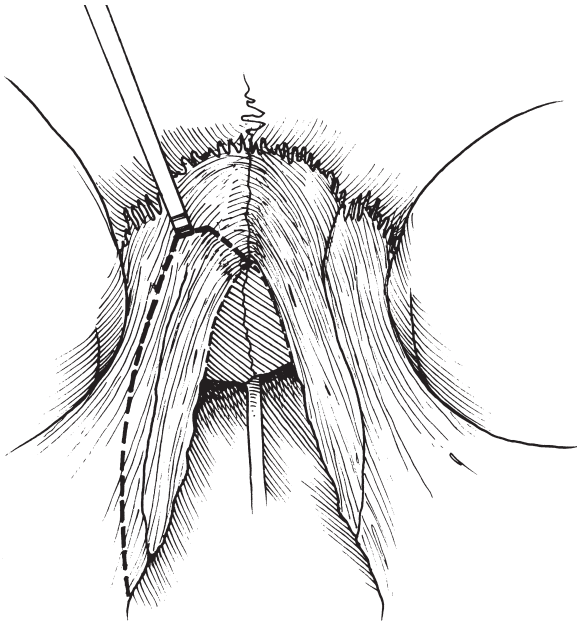


FIGURE 5-24 Percutaneous osteotomies can be used to help medialize a resistant nasal bone by placing a 2-mm osteotome at the proposed back-fracture site. Note how the osteotome follows the proposed path of the back-fracture.

lateral osteotomies through a puncture site along the ascending process of the maxilla. In this case the percutaneous osteotomy is used in lieu of conventional lateral osteotomies.

MIDDLE NASAL VAULT

After completing profile alignment and lateral osteotomies, the middle nasal vault may need to be reconstructed. Patients who have an overly narrow middle nasal vault preoperatively and those with inadequate upper lateral cartilage support will benefit from application of spreader grafts to set the middle vault width. In the “narrow nose syndrome,” patients have short nasal bones and long upper lateral cartilages and a narrow, projecting nose. After dorsal hump removal, these patients tend to demonstrate inferomedial collapse of the upper lateral cartilages and potential nasal valve collapse. In an effort to prevent this problem, these patients can undergo primary application of spreader grafts to set the appropriate middle nasal vault width and prevent inferomedial collapse of the upper lateral cartilages. Spreader grafts are rectangular-shaped cartilage grafts placed between the dorsal margin of the septum and the upper lateral cartilage (Fig. 5-25). Spreader grafts can be applied via the external rhinoplasty approach after the upper lateral cartilages have been freed from the dorsal margin of the nasal septum. Spreader grafts can also be applied via small intranasal incisions made high on the septum. A precise submucoperichondrial tunnel is

created under the intact junction between the upper lateral cartilage and dorsal septum. When applied into a narrow tunnel, the spreader graft produces a cantilever effect and lateralizes the upper lateral cartilage and provides widening of the airway (Fig. 5-26).

STABILIZING THE NASAL BASE

Changes in nasal tip shape should be initiated with stabilization of the nasal base. This can be accomplished by assessing the stability of the medial crura and its relationship to the caudal aspect of the septum. In many patients this relationship is favorable and should not be altered. When using the external rhinoplasty approach, a sutured-in-place columellar strut can be used to help stabilize the base of the nose. This rectangular-shaped cartilage graft can be sutured between the medial crura (Fig. 5-27). The strut increases support of the nasal base and can effectively correct buckled medial and intermediate crura. The columellar strut is sutured between the medial crura with a carefully placed suture to avoid asymmetry or deformity. A 5-0 PDS suture can be placed between the internal surface of the medial crura as they meet the intermediate crura and the graft to stabilize the position of the strut. Placement of the strut also acts as a spacer between the medial crura to reestablish the appropriate width of the columella and simplify realignment of the columellar flap with the reconstructed columella.

On occasion, the caudal septum is overly long and may require shortening to decrease the tension effect of the caudal septum. If the caudal septum is in the midline, the overly long caudal septum can be advanced between the medial crura and sutured into position to stabilize the nasal base without using a cartilage graft (Fig. 5-28). When performing this maneuver, special care must be taken in positioning the medial crura on the caudal septum to avoid creating a retracted columella. Variable positioning can be used to rotate and shorten a nose, increase projection, decrease columellar show, and lengthen the upper lip. We prefer to use a 5-0 chromic transvestibular mattress suture that goes through the cephalic margin of the medial crura and the caudal margin of the septum. This initial fixation suture enables the surgeon to assess the positioning of the nasal tip. Then a 5-0 PDS suture should be used to fixate the caudal septum to the posterior margin of the medial crura to stabilize the reconstruction. If the medial crura are sutured to a normally positioned caudal septum, then a retracted columella or foreshortened nose may be created.

If additional support or nasal length is necessary, a caudal extension graft can be sutured to the existing caudal septum and extended to and sutured between the medial crura to set tip projection, nasal length, and alar/columellar relationship (Fig. 5-29). In most cases the caudal extension should overlap the caudal septum. In some cases the graft will not align in the midline and may

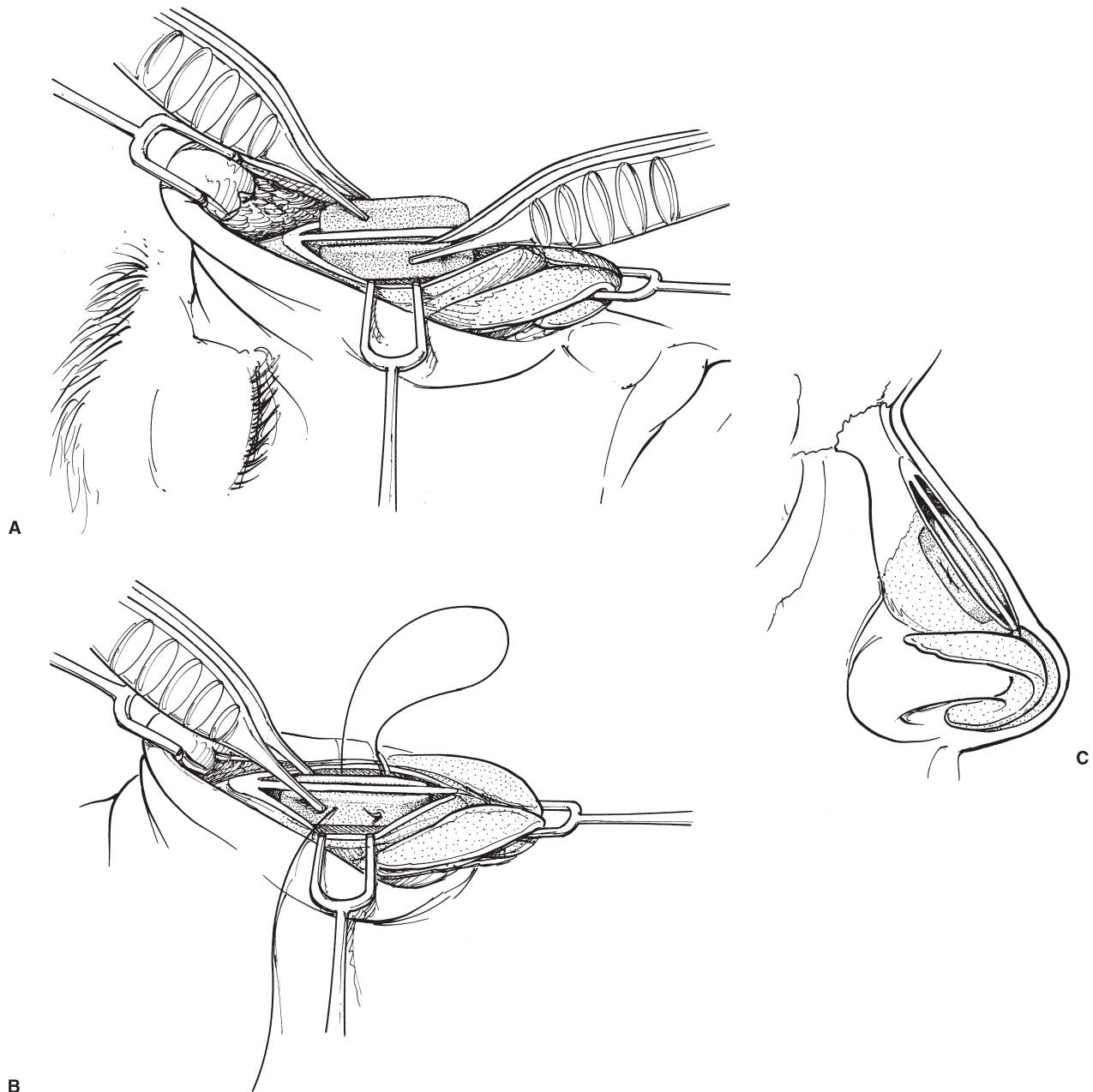


FIGURE 5-25 (A) Spreader grafts applied between the upper lateral cartilages and dorsal septum. Note how the grafts are beveled cephalically to allow them to tuck under the caudal aspect of the nasal bones. (B) A 5-0 PDS mattress suture is used to fix the grafts into position. (C) The upper lateral cartilages are sutured to the spreader grafts to complete the middle vault reconstruction. (From Toriumi DM. Management of the middle nasal vault. *Op Tech Plast Reconst Surg* 1995;2;16–30, with permission.)

need to be oriented end to end with thin splinting cartilage grafts on both sides of the junction. These grafts will prevent rotation of the extension graft. The shape and position of the caudal extension graft can be altered to create different effects on the nasal tip. A rectangular-shaped extension graft acts to lengthen the septum and correct a retracted columella. In the dependent nasal tip, the caudal extension graft can be more projecting along the inferior margin to open the nasolabial angle and create the effect of increasing tip rotation. In the foreshortened nasal tip,

the extension graft can be longer along the anterior margin to increase nasal length. It is critical that the caudal margin of the caudal extension graft be placed between the medial crura in the midline to avoid tip or base asymmetry. Caudal extension grafts provide a powerful means for stabilizing the tip complex and increasing projection while preserving appropriate nasal length.

In some patients, there is inadequate premaxillary support, making it difficult to stabilize the nasal base. Patients with Binder's syndrome have a congenital form of

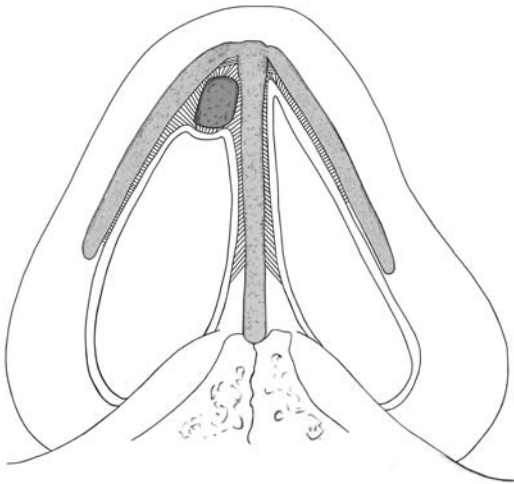


FIGURE 5-26 Spreader grafts applied under an intact connection between the upper lateral cartilages and dorsal septum. If the spreader graft is advanced into a tight submucosal pocket, the upper lateral cartilage is lateralized to open the airway.

premaxillary deficiency. In many of these patients, increasing tip projection is much easier if the deficient premaxilla is augmented first. As an alternative to maxillofacial surgery, the premaxilla can be augmented. Several different materials can be used for premaxillary augmentation. These materials include autologous septal, auricular, or costal cartilage. We prefer not to use alloplastic materials because of the potential for infection and extrusion. Costal cartilage is carved symmetrically and then implanted into a precise pocket over the hypoplastic premaxilla. By augmenting the deficient premaxilla, tip projection can be increased without expanding the tip lobule, which can create excessive tension on the columellar skin closure.



FIGURE 5-27 Sutured in place columellar strut. Note how the strut is placed into a pocket between the medial crura and the normal divergence of the intermediate crura is preserved.



FIGURE 5-28 Suture set back of the medial crura on an overly long midline caudal septum. A straight septal needle is used to suture the back margin of the medial crura to the caudal margin of the septum. Note how the normal divergence of the intermediate crura is preserved.

MANAGING THE NASAL TIP

Once the nasal base is stabilized, an overly wide domal angle or asymmetric tip cartilage can be identified and corrected. With exposure of the lower lateral cartilages, a bulbous nasal tip cartilage can be corrected with conservative cephalic trim of the lateral crura and application of dome binding sutures or a transdomal suture that goes through both domes. Placing a single dome suture through each dome provides greater control over tip asymmetries and creates a more favorable tip contour. Cephalic trim of the lateral crura should be conservative, leaving between 8 and 12 mm depending on the strength of the lateral crura. Strong lateral crura can tolerate larger cartilage excisions with less chance of alar retraction or valve collapse. The most effective and safest method of changing tip shape is by reshaping existing tip cartilages using sutures and not by resection of supportive cartilage.

Dome binding sutures typically pass through the domes in a mattress fashion and compress the domes to narrow the domal angle (Fig. 5-30). We prefer to use 5-0 clear nylon suture for the dome sutures to provide a permanent change in tip shape. Once the dome binding sutures are placed, an additional suture can be placed between the domes to set interdomal width and tip width. The surgeon should avoid excessive pinching of the domes, which can result in deformity and airway compromise. In some cases, the dome binding sutures can result in medial or internal recurvature of the lateral aspect of the lateral crura with obstruction of the airway. Many of these patients already have some degree of recurvature into the airway preoperatively. To manage these patients, we prefer to use lateral crural strut grafts that are placed between the undersurface of the lateral crura and the vestibular skin (Fig. 5-31). The lateral crural strut grafts are stiff rectangular-shaped septal cartilage grafts that act to flatten the lateral crura and prevent their recurvature back into the airway.¹⁰ These grafts can also be used to correct

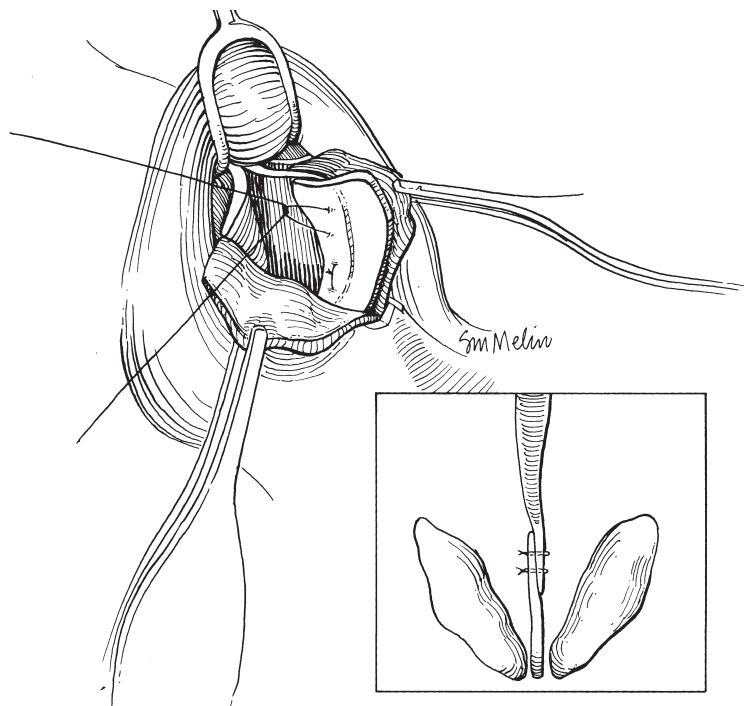


FIGURE 5-29 Caudal extension graft used to increase tip support and set tip projection. Note how the caudal extension graft is overlapped with the existing caudal septum and then sutured between the medial crura. The caudal extension graft must be in the midline caudally and not obstructing the airway posteriorly.

the pronounced curvature of the bulbous nasal tip cartilages (Fig. 5-32). In these cases, lateral crural strut grafts can be sutured to the undersurface of the lateral crura with two or three 5-0 clear nylon mattress sutures to flatten out the bulbous lateral crura. By flattening out the lateral crura, the bulbous shape of the lateral crura can be

eliminated without excessive excision of cartilage. Once the lateral crural strut grafts are in position, two separate dome binding sutures can be applied to set the tip width.

If additional tip projection or tip contour is desired, the surgeon may opt to use a sutured-in-place shield graft to provide a more favorable tip shape. The shield

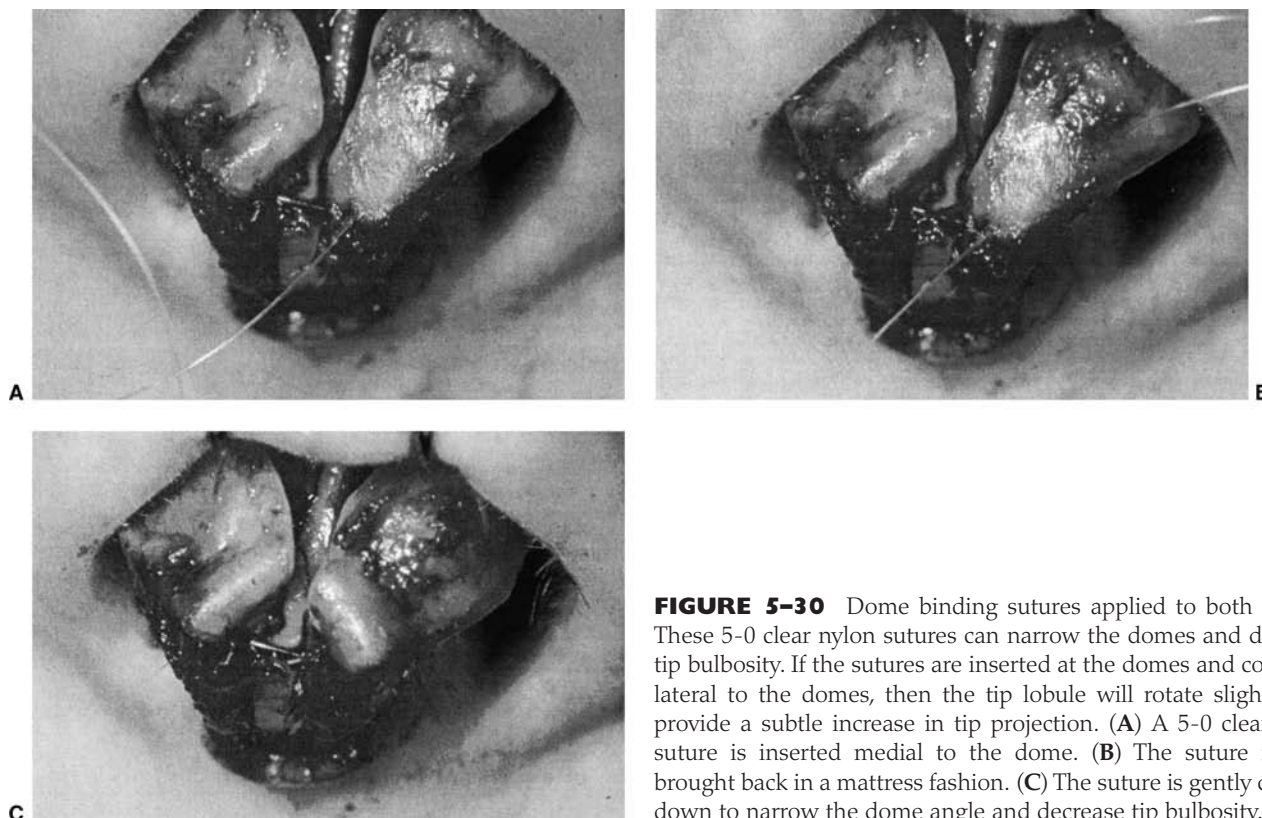


FIGURE 5-30 Dome binding sutures applied to both domes. These 5-0 clear nylon sutures can narrow the domes and decrease tip bulbosity. If the sutures are inserted at the domes and come out lateral to the domes, then the tip lobule will rotate slightly and provide a subtle increase in tip projection. (A) A 5-0 clear nylon suture is inserted medial to the dome. (B) The suture is then brought back in a mattress fashion. (C) The suture is gently cinched down to narrow the dome angle and decrease tip bulbosity.

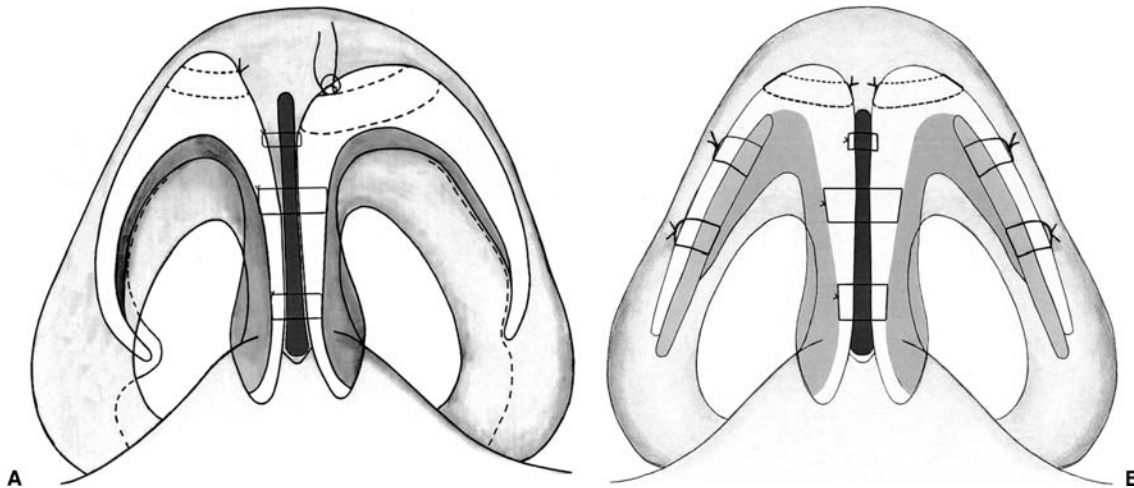


FIGURE 5-31 Lateral crural strut grafts. (A) Placement of dome sutures in a patient with internal recurvature of the lateral crura. The right dome suture is cinched down creating exaggerated internal recurvature of the lateral crura and airway obstruction. (B) Lateral crural strut grafts are placed between the undersurface of the lateral crura and vestibular skin to flatten the cartilage, decrease tip bulbosity, and correct the internal recurvature of the lateral crura. Note how the lateral crural strut grafts flatten out the lateral crura and decrease tip bulbosity. Placement of dome sutures with lateral crural strut grafts allows narrowing of the domes without internal recurvature or deformation of the lateral crura.

grafts are thicker at the leading edge and thinner near the base. The grafts measure 6 to 12 mm in length, 5 to 10 mm in width, and 1 to 3 mm in thickness depending on the purpose of the graft. Shield-shaped grafts are sutured into position with four to six 6-0 PDS sutures placed from the graft to the medial and intermediate crura. Shield grafts are most effective in patients with thicker tip skin. Tip grafts applied in patients with thin tip skin are at high risk of becoming visible over time. Therefore, we avoid tip grafting in patients with thin skin unless tip reconstruction is necessary, as may be the case in severe secondary rhinoplasty cases. If tip grafts are used in these cases, we carefully camouflage the tip graft with lateral crural grafts and cover the leading edge of the graft with a thin layer of perichondrium usually harvested from the posterior surface of the conchal cartilage.

When larger tip grafts are used to increase tip projection, a transitional gap is created between the leading edge of the tip graft and the existing dome cartilages. In an effort to create a smooth transition from tip graft to dome cartilage, the surgeon can place a cartilage cap or buttress graft between the cephalic margin of the tip graft and the existing dome cartilages (Fig. 5-33). The objective is to create a smooth transition from the edge of the tip graft to the existing domes. This smooth transition minimizes the possibility of visibility of the tip graft. There should be a smooth transition from the leading edge of the tip graft to the caudal margin of the lateral crura and domes. Buttress grafts are particularly important in patients who require significant tip projection with a relatively tight skin closure over the projected tip structures. Lateral crural grafts can also be used to

support tip grafts and create a favorable transition from tip graft to existing domes.

SEPTAL PERFORATIONS

Septal perforation repair can be performed using the external rhinoplasty approach. The exposure provides maximal visualization of the septal perforation as well as maximal mobilization of bipediced superior and inferior mucoperichondrial flaps. Typically, perforations less than 2 cm can be successfully closed using this technique. Patients with a larger nose can undergo closure of larger perforations. Location of the perforation is also a critical factor in determining the ability to close a septal perforation. Septal perforations measuring less than 2 cm and located in the central septum can usually be closed with mucoperichondrial flaps. The perforation can be closed using bipediced mucoperichondrial flaps from above and mucosal transposition flaps from below. These flaps have a robust blood supply and can be transposed into large septal defects without compromising their blood supply. A biologic membrane should be placed between the reconstructed flaps to provide a platform for migration of mucosa across small residual defects in the reconstruction. Acellular dermis (Alloderm, LifeCell, Boston, MA) is an ideal biologic material that can be placed between the reconstructed flaps to support the reconstruction and maximize the results of the closure. Prior to closure, the margins of the perforation should be freshened by stripping the internal diameter of the perforation. By removing this mucosalized margin, the perforation can close as the mucosa heals. Posterior perforations are much more difficult to close because of more difficult access. Patients with larger septal



FIGURE 5-32 Patient with bulbous nasal tip and internal recurvature of the lateral crura. Lateral crural strut grafts were placed to flatten the lateral crura and correct the internal recurvature. The medial crura were sutured to the caudal margin of the septum to correct the hanging infratip lobule. Profile alignment was achieved using conservative hump reduction and a crushed cartilage radix graft. Preoperative views: A, C, E, and G. Postoperative views: B, D, F, and H.

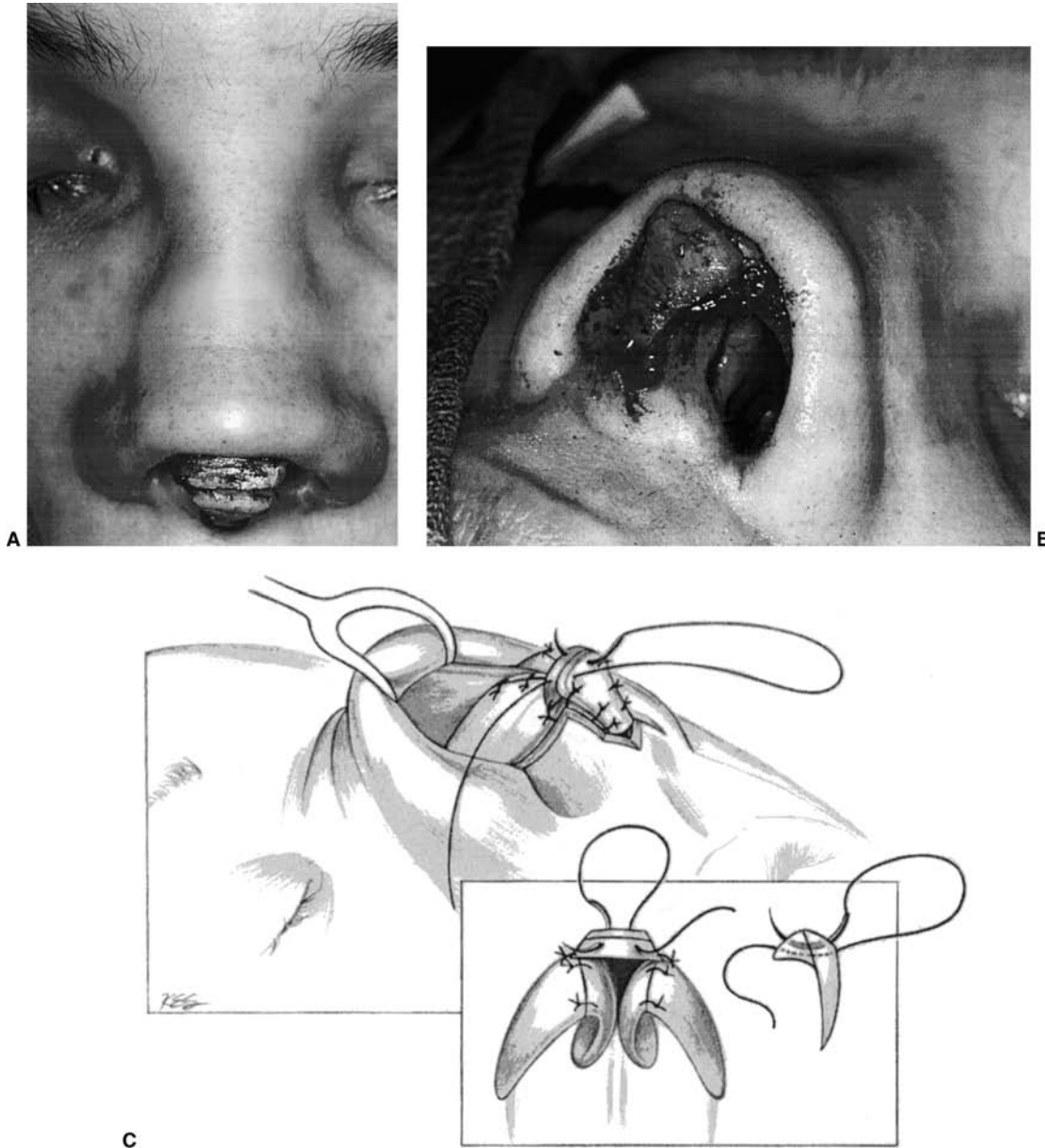


FIGURE 5-33 (A) Tip graft with buttress graft sutured behind the graft to support it and provide a better transition from tip graft to surrounding tip structures. (B) The buttress graft is sutured to the existing domes. (C) Note how the buttress graft is sutured to the domes to stabilize the leading edge of the tip graft and create a smooth transition from tip graft to domes.

perforations who are not candidates for closure can frequently control their symptoms by performing nasal irrigation to keep the margins of the perforation clean.

NASAL VALVE SURGERY

The nasal valve is bounded by the caudal margin of the upper lateral cartilages, nasal septum, floor of the nose, and inferior turbinate. Internal nasal valve collapse is due to inferomedial collapse of the caudal margin of the upper lateral cartilages. Internal nasal valve collapse is usually seen after previous rhinoplasty or in patients with lateral wall weakness (narrow nose syndrome, etc.). Correction of

internal nasal valve collapse usually requires application of spreader grafts to reposition the upper lateral cartilages or by placing lateral wall grafts such as alar batten grafts. Alar batten grafts are curved cartilage grafts that are placed into a pocket at the point of maximal lateral wall collapse (Fig. 5-34). Alar batten grafts can create some fullness along the lateral wall of the nose that may persist for several months but eventually will become less prominent. External nasal valve collapse occurs when there is inadequate lateral wall support and the alae collapse on moderate to deep inspiration through the nose. This is most frequently seen in patients with cephalic positioning of the lateral crura. These patients have no cartilage support

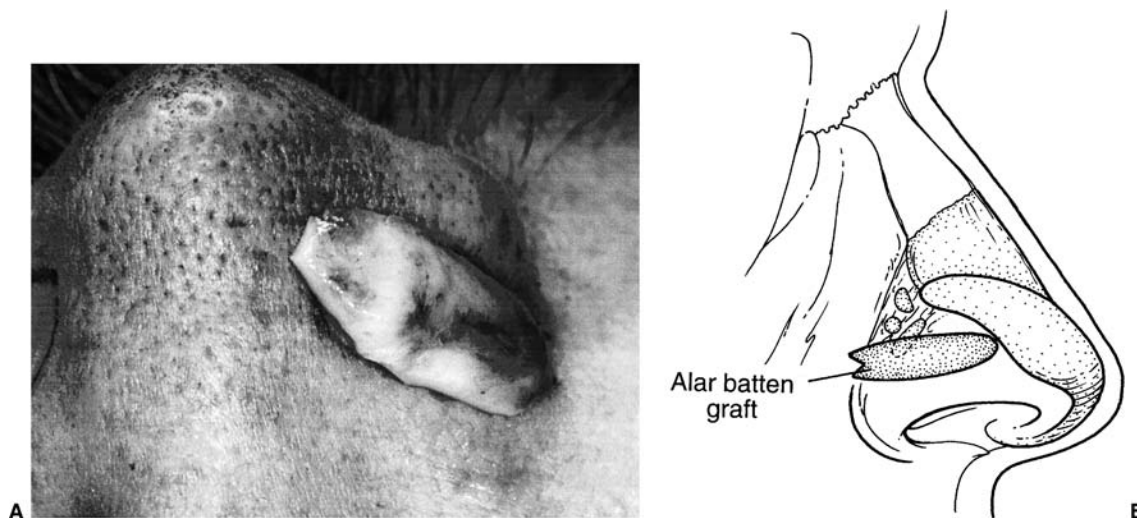


FIGURE 5-34 (A) Alar batten grafts are curved cartilage grafts that are placed into pockets at the point of maximal lateral wall weakness or collapse. Typically, the convex surface of the graft is oriented laterally. Auricular cartilage is ideal for alar batten grafts as it has a favorable curvature to lateralize the collapsed lateral wall. (B) The grafts are usually placed caudal to the existing lateral crura. For maximal correction the grafts should overlap the pyriform aperture.

laterally and tend to have slit-like nostrils, projecting nasal tip, and thin alae. Correction of external nasal valve collapse requires placement of alar batten grafts into a precise pocket closer to the alar margin.

DEVIATED NOSE

The deviated nose can be analyzed according to the site of the deviation. Some patients have deviations limited to the bony nasal vault. In these cases, execution of medial and lateral osteotomies may be sufficient to correct the

deviation. In severe deviations of the bony vault, camouflage onlay grafting with small crushed cartilage grafts may be necessary to completely correct deviations. These grafts can be placed into small precise pockets at the site of residual concavity. Deviations of the middle nasal vault can be corrected by freeing the upper lateral cartilages from the dorsal margin of the nasal septum. Simply freeing the upper lateral cartilages from the septum may result in some straightening of the dorsal septum. If a residual deviation of the dorsal septum persists, the cartilage can be crosshatched on the concave side to release its

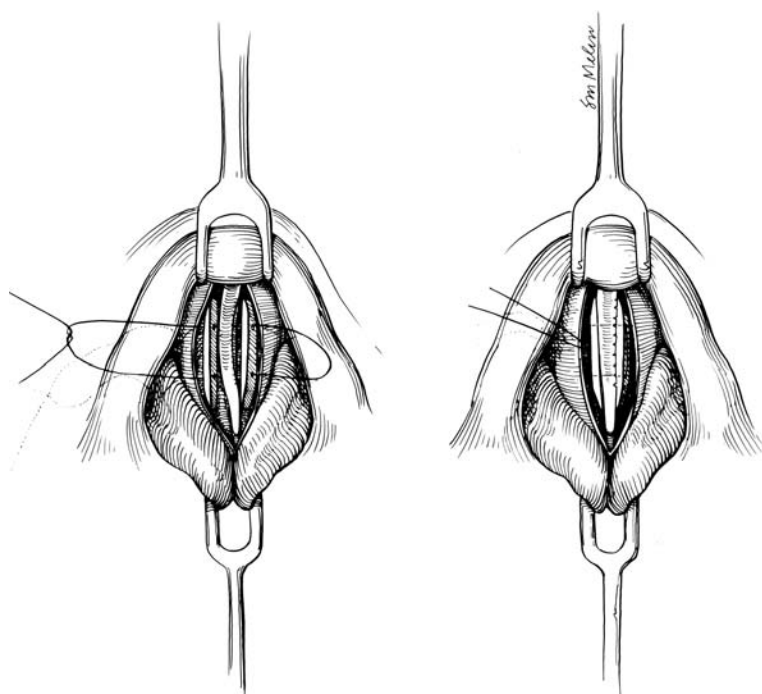


FIGURE 5-35 Splinting/spreader grafts can be used to straighten the dorsal septum. (A) The deviated dorsal septum can be crosshatched on the concave side and then splinted by the spreader grafts. It is preferable to use a thicker spreader graft on the concave side of the deviation. (B) The splinting/spreader grafts are sutured to the dorsal septum followed by suturing of the upper lateral cartilages.

memory and then splinted with splinting/spreader grafts. These splinting/spreader grafts can be very effective for straightening dorsal septal deviations and deformities of the anterior septal angle (Fig. 5–35). Severe deviations of the dorsal septum or caudal septum with vertical fractures may require more aggressive methods of correction. In some of these cases, we use techniques of septal reconstruction using straight segments of septal cartilage harvested from the posteroinferior septum to reconstruct the severely damaged portion of the septum (Fig. 5–36). Most caudal septal deviations can be corrected by freeing the inferior aspect of the caudal septum from the nasal spine and maxillary crest. Excessive cartilage height can be trimmed to allow the caudal septum to swing freely. Then the caudal septum can be sutured to the periosteum around the nasal spine to fixate the caudal septum into the midline. In most cases, the cartilage should be cross-hatched on the concave side of the deviation to release the memory of the cartilage and allow it to swing freely. In some patients, the nasal tip is asymmetric due to deformity of the lower lateral cartilages. In these cases, the lower lateral cartilages usually need to be dissected to allow correction of the asymmetries and stabilization so the asymmetries do not recur. The external rhinoplasty approach is ideal for patients with deviations of the middle nasal vault and with asymmetrical nasal tips. The extended exposure of the lower two thirds of the nose allows symmetric reconstruction of the middle nasal vault and lower lateral cartilages.

MANAGING THE WIDE ALAR BASE

Patients with a wide alar base may require some form of alar base narrowing or modification. When considering making such changes, it is important to make an accurate diagnosis of the problem. The length of the outer alar circumference, internal nostril circumference, and width of the nasal base can be determined, and then a decision can be made on the most effective means of treating the alar base (Fig. 5–37). If the outer alar circumference is excessive with normal or small nostrils, then excision of the outer diameter of the ala can be performed without violating the internal diameter of the nostril. In these cases, the scar on the lateral alar base will be visible and may take many months to improve. If closed with a slight favorable bevel, then the incisions will camouflage nicely over time. If the internal nostril circumference is excessive or if the ala flares, correction may require resection of a triangular-shaped segment of skin from the internal lateral nostril margin. The more lateral the excision, the more significant the correction of nostril flare. A more medial excision along the nostril sill acts to narrow the nasal base. Any incisions made along the nostril sill should have a favorable bevel to increase skin edge eversion and form a better scar. Reduction of the internal diameter of the ala also decreases the size of the nostrils. Therefore, this type of alar reduction should be performed only in cases where

the nostrils are excessively enlarged. It is preferable to use conservative excisions to avoid excessive narrowing of the nostrils. Internal alar base reduction should be avoided in patients with small or appropriately sized nostrils. Patients who have a wide alar base can also be improved by performing a sliding alar flap.³ In this case, a segment of tissue is excised with a back cut that allows the ala to be advanced medially. In patients with a very wide nasal base, an alar base bunching suture can be used to further narrow the nasal base (Fig. 5–38). In these cases, a 3-0 Mersilene suture is passed from incision to incision under the feet of the medial crura. Care is taken not to cinch this suture too tightly because it can create deformity. When performing alar base reduction, one can perform 70% of what one would anticipate to be an ideal excision to avoid overexcision, yet leave the patient with a reasonable improvement. It is particularly important to avoid overexcision of the alar base in male patients.

OPTIONS FOR GRAFTING IN RHINOPLASTY

When harvesting auricular cartilage, the surgeon can use either an anterior or posterior approach. The advantage of using the posterior approach is that the scar is hidden behind the ear and there tends to be less deformity of the ear. The anterior approach may be easier to harvest the cartilage; however, closure of the incision can be difficult because of the tendency for the skin edges to overlap. When harvesting auricular cartilage, the cavum and cymba cartilage are usually removed. The surgeon should try to leave the vertical component of the conchal bowl intact if the patient is concerned about the ear being set back closer to the side of the head. If one ear sticks out further than the other, then the cartilage can be harvested from the ear that is more prominent. The surgeon should also ask patients if they sleep on their side. If they do, the cartilage should be harvested from the side they don't sleep on. Auricular cartilage is more difficult to work with because it is not flat like septal cartilage and may warp or deform. Therefore, it is important to carve the auricular cartilage carefully and bevel the edges appropriately. This is particularly important when auricular cartilage is used for dorsal augmentation because this is the area where the auricular cartilage is most likely to deform or become visible over time. There is less risk in using auricular cartilage as a tip graft, lateral crural graft, alar batten graft, or spreader graft. In fact, auricular cartilage is the preferred grafting material for alar batten grafts and lateral crural grafts because of its gentle curvature and softer character. In many cases, auricular cartilage works well for tip grafts because of its curvature, which can create a favorable shape to the infratip lobule. If a straight segment of cartilage is needed, the auricular cartilage can be gently cross-hatched or two pieces of auricular cartilage can be sutured with the curved surfaces opposing each other.

In some cases we use autologous costal cartilage, which is ideal for major structural support in patients

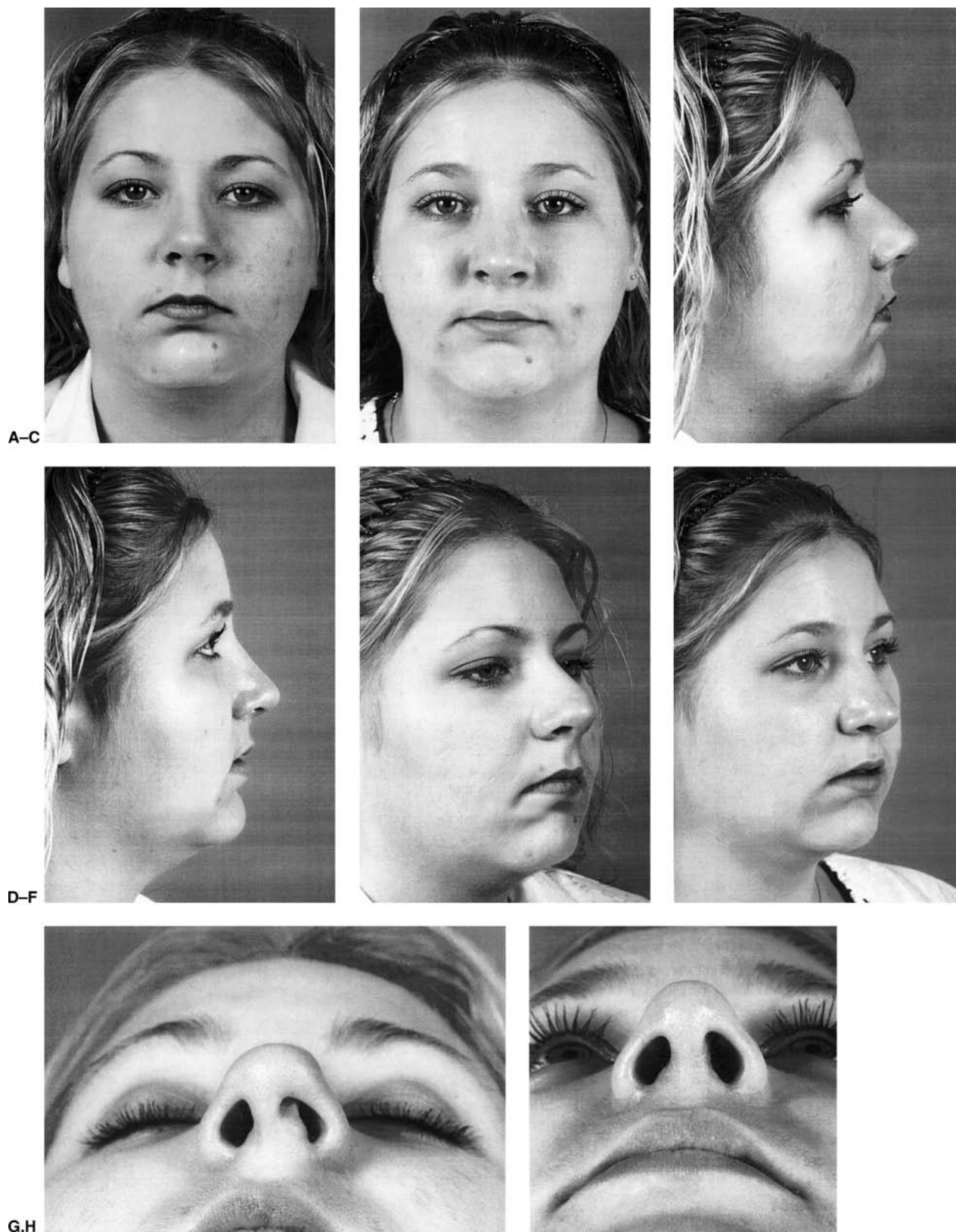


FIGURE 5-36 Patient with a severe caudal septal deviation and a vertical fracture with near complete obstruction of the right nasal airway. Frontal view reveals significant asymmetry of the nasal tip and base with nostril asymmetry. Correction required subtotal septal reconstruction with removal of the fractured segment and reconstruction of the L-shaped septal strut. Preoperative views: A, C, E, and G. Postoperative views: B, D, F, and H.

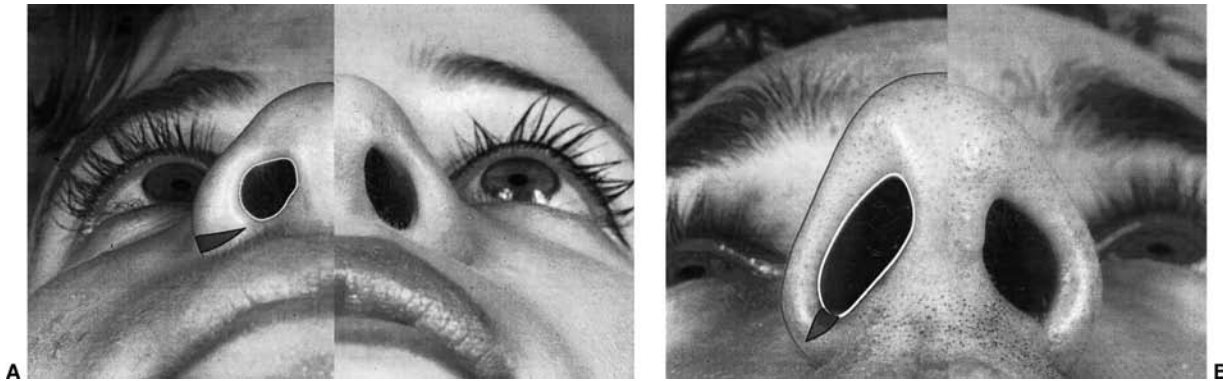


FIGURE 5-37 Evaluation of the external circumference of the ala and internal circumference of the nostril can help determine the best technique to correct alar base deformities. (A) In this case, there is excess outer circumference and a relatively small internal nostril circumference. Excision of the lateral circumference of the ala will decrease the outer circumference of the ala. These incisions will not affect the size of the nostril unless the excision is extended into the nostril. In this case the nostril takes on a more oval shape due to increasing tip projection and decreasing the lateral alar circumference. Preoperative: left. Postoperative: right. (B) Internal alar base reduction can be used to decrease nostril flare and decrease size of the nostril opening. Incisions placed more medially on the nostril sill will narrow the base of the nose. Incisions placed more laterally will create the effect of decreasing nostril flare. In this case, the excision is more lateral to decrease nostril flare and decrease the size of the nostril. It is important to create a favorable bevel to the skin incision to accentuate eversion of the skin edges. Preoperative: left. Postoperative: right.



FIGURE 5-38 Wide alar base with excess lateral alar circumference and excessively large horizontally oriented nostrils. (A) A full-thickness excision was performed to decrease outer alar circumference and internal nostril size. Preoperative: left. Postoperative: right. (B) In addition, an alar base bunching suture of 3-0 Mersilene was used to further narrow the nasal base. This suture goes from excision to excision and passes under the feet of the medial crura. Tip projection has been increased with a columellar strut and tip graft.

needing a major increase in tip projection, correction of saddling, or premaxillary augmentation. Costal cartilage is associated with warping if it is not carved properly. Costal cartilage must be carved symmetrically from the center of the harvested rib to leave a graft that will heal with equivalent forces of contracture on opposing sides of the graft.¹¹ If not carved properly, the costal cartilage graft tends to warp. One can readily assess the likelihood of warping by placing the carved costal cartilage graft into saline solution for a period of time. If early warping is noted, then it is more likely to warp when implanted in the patient. In this case, additional carving can be performed to decrease the tendency toward warping.

There are several homologous options for the surgeon that can be used in select instances. Irradiated homograft

costal cartilage is a good option for dorsal augmentation in older patients who are not good candidates to use their own autologous tissues. As with autologous costal cartilage, homograft costal cartilage can warp and requires symmetric carving.

There are many forms of alloplastic materials that are available to the surgeon for rhinoplasty. Gore-Tex (expanded polytetrafluoroethylene, W. L. Gore) comes in the form of soft tissue patches and is a popular material for dorsal augmentation in rhinoplasty. Gore-Tex is microporous and allows for some soft tissue ingrowth. Medpore is polyethylene and has a larger pore size, which allows greater tissue ingrowth. Silastic is without pores and forms a capsule because it does not allow soft tissue ingrowth. Silastic remains a popular material for dorsal and columellar

augmentation. With all alloplastic materials there is risk of infection, mobility, or extrusion. If an alloplastic implant should become infected or chronically inflamed, there is a potential for severe damage to the overlying skin–soft tissue envelope. Additionally, the skin–soft tissue envelope may thin over an alloplastic implant, leaving atrophic skin that is very difficult to dissect.

REVISION AND SECONDARY RHINOPLASTY

Revision and secondary rhinoplasty must be approached differently from primary rhinoplasty as the nose has been previously operated and in most cases a functional and aesthetic problem must be corrected. Revision rhinoplasty usually requires a correction that surgeons must make on a nose that they previously operated on. Secondary rhinoplasty refers to a corrective surgical procedure made on a nose that was previously operated on by a different surgeon. In both cases, the degree of correction can be major or minor. Some operations are reductive and require only additional reduction of the nasal dorsum or nasal tip. For example, the patient with a slight residual dorsal hump may require only rasping of the nasal dorsum. These are ideal cases for use of the power burr (Rhinobur, Medtronic/Xomed, Jacksonville, FL). On the other hand, many patients require addition of cartilage grafting material to correct problems associated with overreduction of the nasal structures. In these patients, grafting materials are necessary to correct the structural or contour defect. Autologous materials are always preferred over alloplastic materials because of the long-term reliability of autologous grafts. Autologous septal or auricular cartilage is preferred. In many cases, septal cartilage can be harvested despite the patient's having undergone previous septal surgery. If septal cartilage is not available, the surgeon can harvest autologous auricular cartilage from the ear.

One of the more common deformities seen after rhinoplasty is the polybeak deformity, which usually occurs

due to an unexpected postoperative loss of nasal tip projection. The loss of projection results in increased prominence of the supratip, leaving the characteristic polybeak deformity. This deformity can also be due to overreduction of the nasal dorsum in a patient with thick skin. In this scenario, the thick skin–soft tissue envelope is not able to contract over the reduced structure and leaves a redundancy of tissue in the supratip region. In other cases, the surgeon may leave an excess of anterior septal angle that creates fullness in the supratip region. Polybeaks can be prevented by effectively stabilizing the nasal base so there is little loss of projection postoperatively. The surgeon can also leave the dorsum higher in patients with thick skin. This provides better redraping of the thick skin over the entire nose. Creating balance in the nose is critical to success in rhinoplasty. Patients who have a low dorsum will benefit by elevating the dorsum to better balance the nasal tip.

Patients who have undergone previous overreductive nasal surgery frequently have functional problems in addition to the aesthetic deformities. Deformities of the nasal dorsum can usually be corrected by performing osteotomies, rasping or using the power burr, or by camouflaging or augmenting the dorsum. If dorsal augmentation is planned, the surgeon can anticipate this maneuver and leave a precise dorsal pocket to accept the dorsal graft. Placement of the graft into a precise pocket minimizes the chances of graft movement or displacement. If a radix graft is planned, then a narrow subperiosteal pocket should be left in the radix region to accept the graft and minimize the chance of graft displacement. When applied through the external rhinoplasty approach, dorsal grafts can be sutured directly to the middle nasal vault to avoid movement. Special care must be taken to bevel the edges of the graft to provide a smooth transition from graft to middle vault. It is more favorable to have a single piece of cartilage that spans the dorsum from radix to supratip. This length of graft is less

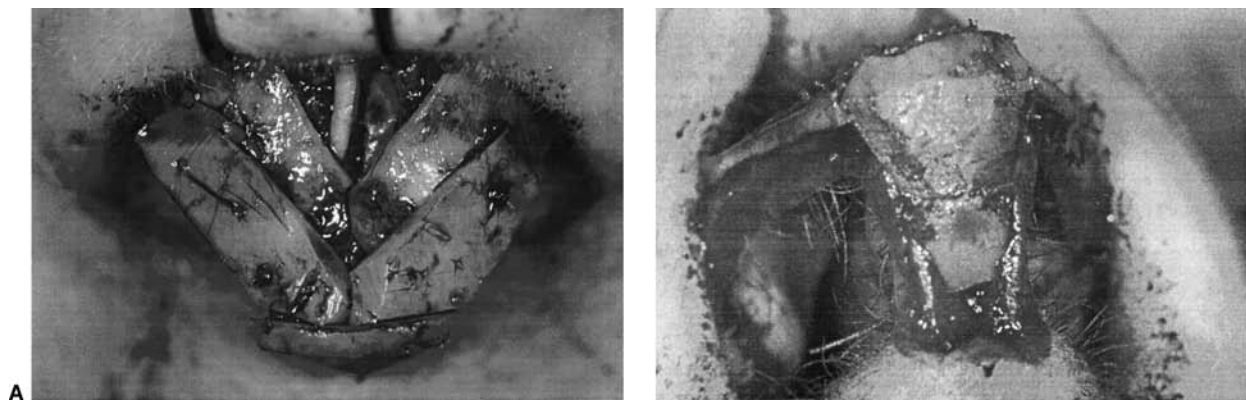


FIGURE 5-39 (A) Tip graft and lateral crural grafts used to reconstruct a previously overresected nasal tip. The lateral crural grafts act to support the tip graft. (B) Note how the lateral crural grafts are sutured to the tip graft at an oblique orientation. This structure will be covered with a thin layer of perichondrium to help camouflage the edges of the grafts.

likely to become displaced or visible. In some cases, double-layered grafts may be necessary to provide appropriate dorsal augmentation.

Inferomedial collapse of the upper lateral cartilages can result when there is inadequate support of the upper lateral cartilages after dorsal hump removal. In these cases, the upper lateral cartilages collapse inferomedially, resulting in excessive narrowing of the middle nasal vault and formation of the inverted-V deformity.^{3,5} The inverted-V deformity is rarely due to dislocation of the upper lateral cartilages from the caudal margin of the nasal bones. In most cases it is due to collapse of the upper lateral cartilages with overreduction of the bony dorsum and inadequate closure of the open roof. This deformity is most frequently seen in patients with short nasal bones and long upper lateral cartilages (narrow nose syndrome).^{3,5} Correction requires application of spreader grafts, which can be placed after freeing the upper lateral cartilages from the septum or under an intact connection between the upper lateral cartilages and dorsal septum. Spreader grafts can also be used to straighten a collapsed and deviated middle nasal vault.

Correction of nasal tip deformities is complex and requires more advanced cartilage grafting maneuvers. If the lateral crura have been previously overresected, they can be reconstructed with a tip graft and lateral crural grafts (Fig. 5-39).^{1,12} These grafts are placed over the existing lateral crura (if present) and fixed with transvestibular chromic sutures and 5-0 PDS sutures. Once sutured into position, a shield graft can be sutured to the caudal margin of the medial crura and to the caudal margin of the lateral crural grafts to create a stable tip reconstruction. The lateral crural grafts provide support to the alar margins and can re-create a triangular shape to the nasal base (Fig. 5-40).

If a patient has internal nasal valve collapse and supra-alar pinching, correction may require placement of alar batten grafts into precise pockets at the point of maximal lateral wall collapse.^{12,13} Curved auricular cartilage is ideal for an alar batten graft because the convex surface of the graft can be placed laterally to correct the supra-alar pinching and open the nasal valve. In patients with severe internal nasal valve collapse, the alar batten grafts should extend out to the pyriform aperture. Internal vestibular splints can be placed into the nasal vestibule to help stabilize the alar batten grafts while they heal in the proper position. In patients with severe airway compromise, internal vestibular splints can be worn long term with the patient using the splints while they sleep. Using the splints creates fullness along the lateral wall of the nose. This fullness gradually decreases, ultimately leaving the patient with a good long-term improvement in airway breathing and a good aesthetic result as well. Some residual fullness along the lateral wall is to be expected.

Alar retraction usually results from excessive resection of the lateral crura, and the resultant scar contracture pulls the alar margin cephalically. Milder forms of alar

retraction can be corrected with application of lateral crural grafts or alar rim grafts. More severe cases of alar retraction may require placement of cartilage and skin composite grafts into a precise pocket along the point of maximal alar retraction. After making a marginal incision, the skin of the alar margin is unfurled and the composite graft is inserted and sutured into place with four or five 5-0 chromic sutures. Placement of too many sutures may result in failure of the composite graft by limiting vascular ingrowth from the surrounding tissues.

AGING NOSE

Surgery of the aging nose requires some modifications in surgical technique and conservative aesthetic goals. Patients in midlife tend to prefer more conservative aesthetic changes such as leaving a higher dorsal profile and making conservative changes in nasal length, narrowing, and tip rotation. Additionally, preservation or improvement in nasal function is particularly important in this patient population. These patients frequently need structural grafts such as alar batten grafts to support the lateral wall of the nose. Spreader grafts may also be necessary if the middle vault is narrow.

Older patients tend to have thinner skin with less sebaceous activity, and dissection in the proper tissue plane is particularly important to avoid thinning of the skin. Any grafts placed in these patients have a greater tendency to become visible because of the thinner overlying skin-soft tissue envelope. Nasal skin in older patients is less apt to contract over time. Therefore, these patients must be satisfied with slightly larger nasal shapes to allow proper draping of the nasal skin after reduction. The nasal bones in older patients are more brittle and will be at greater risk for overnarrowing with osteotomies and infracture. Therefore, greenstick fractures in older patients are acceptable and allow more conservative narrowing of the bony vault.

ILLUSIONS IN RHINOPLASTY

When performing rhinoplasty, surgeons can use illusions of nasal contour to effect visual changes in nasal length, projection, and tip rotation. Perceived nasal length is based on several variables including position of the nasal starting point and tip defining points, as well as the attitude of the nasolabial angle. A short nose can be altered in several ways without actually lengthening the nasal structure. If the patient has a low radix, application of a radix or dorsal graft sets the nasal starting point at a higher level and provides the illusion of a longer nose. The nose can be made to appear longer also by decreasing the projection of the nose. Less projected noses appear longer than overprojected noses of the same length. A long nose can be made to appear shorter by increasing projection and dorsal height. An overprojected nose appears less obtrusive by increasing projection of an underprojected chin. An overprojected nose

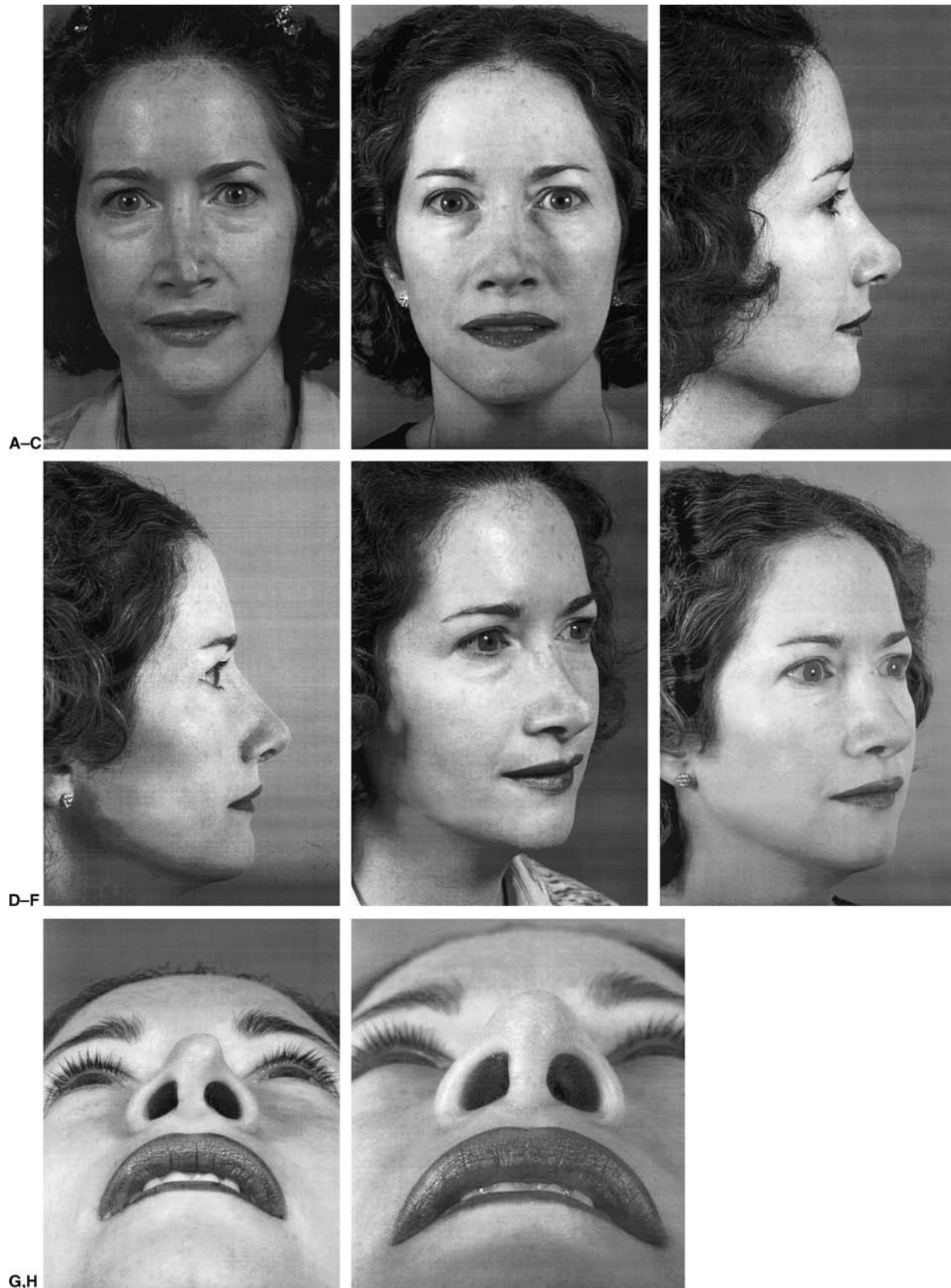


FIGURE 5-40 This patient has undergone previous external rhinoplasty with vertical dome division, resulting in nasal valve collapse and a pinched, asymmetric nasal tip. She also has a collapsed middle vault with deviation. Her primary complaint was nasal obstruction. She underwent a secondary rhinoplasty with placement of spreader grafts, and tip reconstruction with lateral crural grafts, tip graft, and alar rim grafts. Alar batten grafts provided support to the lateral nasal wall and helped to correct the nasal valve collapse. Postoperatively her nasal function was dramatically improved. Preoperative views: A, C, E, and G. Postoperative views: B, D, F, and H.

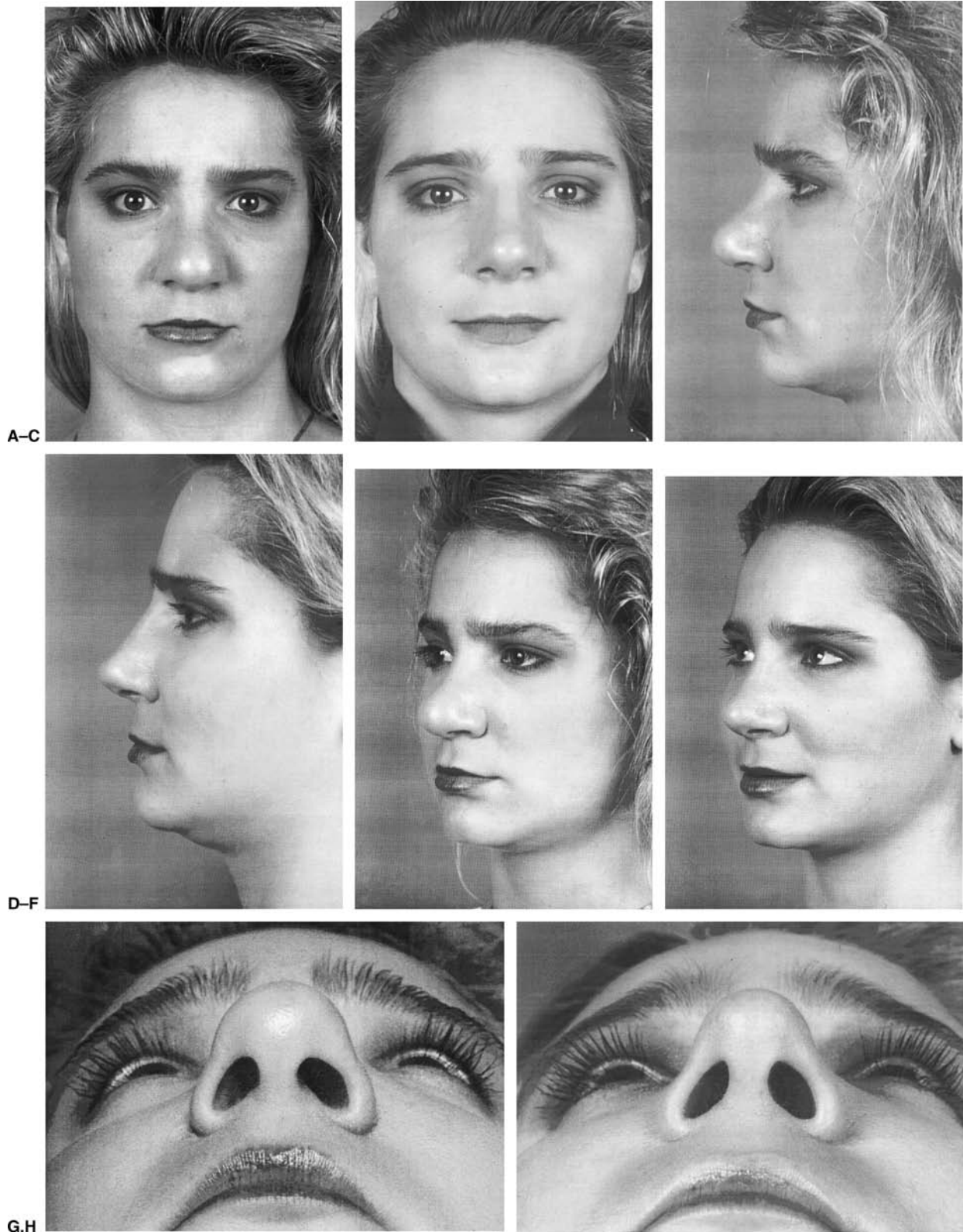


FIGURE 5-41 Patient with thick skin and bulbous nasal tip. The nose is unbalanced with a lower nasal dorsum and projected nasal tip. Reduction of this nasal tip would likely result in a polybeak deformity. In this case the nasal dorsum was augmented to bring the dorsum up to the level of the supratip. A tip graft was used to project into the thick skin and create better tip shape. Preoperative views: A, C, E, and G. Postoperative views: B, D, F, and H.

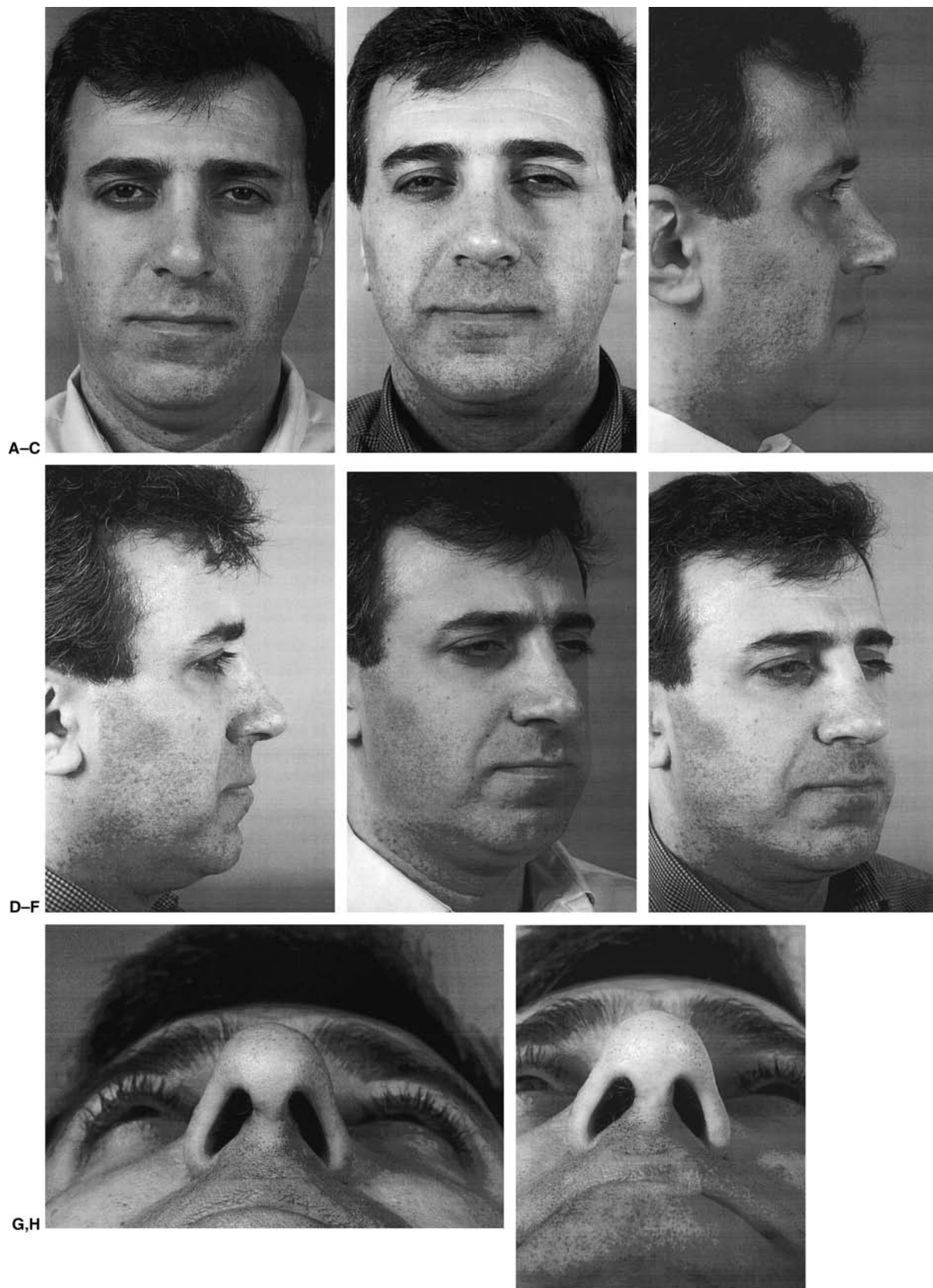


FIGURE 5-42 This patient underwent previous reductive rhinoplasty via the external rhinoplasty approach. The thick skin did not contract and left the patient with a polybeak deformity. To help balance the nose, the dorsum was augmented and a tip graft was used to expand the nasal tip skin. Chin augmentation was performed to help balance the increased tip projection and overall larger nose. Preoperative views: A, C, E and G. Postoperative views: B, D, G, and H.

looks less projected if the nasal dorsum is elevated to balance the tip projection. Patients with thick nasal tip skin are benefited by increasing tip projection and augmenting the nasal dorsum. In these cases, the augmentation allows expansion of the thick skin to provide a more refined frontal view (Fig. 5–41). An overrotated nasal tip can be improved by reducing tip projection and creating a more acute nasolabial angle. This can be accomplished by correcting septal deviations and possibly by using a caudal extension graft. Use of these illusions makes modification of abnormal nasal contours much easier for the surgeon.

CHIN AUGMENTATION

Many patients undergoing rhinoplasty may have an improved outcome if the surgeon performs a concurrent chin augmentation. Patients with an overprojected nose and poorly projected chin are ideal candidates for chin augmentation. Patients who have a large, thick-skinned nose are difficult to manage because if the surgeon makes the nose too small, the skin does not contract and may leave the patient with a polybeak deformity. It is preferable to leave noses with thick skin larger to maximize redraping of the nasal tip skin and lend a more refined frontal appearance to the nose. If the patient should have a poorly projected chin, augmentation of the chin increases the projection of this facial feature and allows the surgeon to leave a larger nose that looks balanced with the surrounding facial features (Fig. 5–42).

When performing chin augmentation, we prefer to use extended anatomic chin implants. The extended implants provide a more natural chin/mandible contour and avoid the appearance of an isolated pointed chin prominence. The extended chin implants are also more stable because they can be placed subperiosteally laterally. We place the implants supraperiosteally medially and create subperiosteal tunnels laterally. We also choose what we feel would be the ideal chin projection for the patient and then augment only 60% to 70% of that ideal projection. By using this method, the surgeon provides a favorable improvement in the chin augmentation without creating deformity.

FINAL COMMENTS

Rhinoplasty has changed dramatically over the past decade and is now an operation of increasing structure with less resection and reduction. Aggressive resection techniques are no longer considered effective techniques, as many of these patients develop nasal obstruction and deformity many years after surgery. It is imperative that nasal function be preserved or improved.

Compromising nasal function for aesthetics is detrimental and hurts the patient in the long term.

Rhinoplasty is a complex operation that is affected by many variables that make prediction of the final outcome very difficult. Only experience and constant education enable the rhinoplasty surgeon to become proficient at this operation. We recommend that surgeons keep precise graphic records of what was done at the time of surgery to allow one to refer back to the maneuvers performed during the operation. Precise record keeping allows surgeons to alter their techniques to improve their long-term aesthetic and functional outcomes. To become a better rhinoplasty surgeon requires a lifetime of study and self-assessment.

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AGING-FACE SURGERY

Edward Farrior

As society reaches for the Fountain of Youth, there are still some physical changes that come with aging that can be postponed but cannot be eliminated by antioxidants, hydration, and exercise. It is the effect of these processes and the change in the underlying skeletal framework that makes aging-face surgery necessary to maintain youthful appearance. The causes of these changes in texture, resilience, and appearance of the skin, as well as the muscular, fascial, and skeletal support mechanisms, need to be understood and addressed in the context of the aging process. A plethora of surgical procedures have evolved to reverse this process with the goal of rejuvenation. The isolation of facial regions is useful in the evaluation, but a more global approach to the correction of these stigmata prevents facial disharmony in rejuvenation.

The global approach to analysis for facial rejuvenation begins with the skin and proceeds layer by layer until skeletal abnormalities are considered. For the purpose of this chapter, the facial components are discussed with respect to their regional impact and in the context of the overall process (Fig. 6-1).

PATHOGENESIS

There are intrinsic and extrinsic changes that occur in the skin that, in combination with congenital variations in the skeletal framework and soft tissue, lead to the characteristic changes that occur in the aging face. Intrinsic changes are generally considered changes in the substance, whereas extrinsic changes are alterations in the structure. Both processes affect the epidermis, dermis, and subcutis. Intrinsic changes may also occur in the skeletal framework.

The intrinsic changes, which occur within the epidermis, include flattening of the dermal-epidermal junction, retraction of the rete pegs, changes in the size and shape of the basal cells, decreased height and adhesiveness of the keratinocytes, and loss of moisture within the stratum corneum.¹ The perceived effect of these changes contributes to the fragility of the skin as one ages, as well as the roughness of texture and dryness. The fragility is usually due to the flattening of the dermal-epidermal

junction and retraction of the rete pegs. Roughness is the result of loss of moisture and the thinning of the stratum corneum.

The dermis itself is not immune to intrinsic changes. There is a decrease in dermal thickness that occurs throughout life, which is accompanied by an ongoing decrease in collagen content at 1% per annum. Elastic within the skin becomes atrophic, resulting in a loss of resilience, or the ability to return to its original shape after stretching. These changes lead to the laxity and redundancy of skin. The subcutis is affected by a loss of fat as time proceeds, also leading to perceived skin laxity and a gaunt, wasted appearance.

Skeletal and soft tissue support of the skin also undergoes intrinsic changes contributing to the aging face. These changes may be dramatic or subtle in their effect, and may influence some of the choices made regarding surgery. Thinning of the skull, resorption of alveolar bone and descent of the hyoid bone and larynx, and buccal and temporal face resorption all impact the facial characteristics, which exacerbates the skin laxity and aging process.

Congenital contributions may affect the aging process. Thicker-skinned people with increased sebaceous content tend to develop fewer wrinkles during the aging process. Increased subcutaneous fat content also helps prevent some of the subtle signs of aging within the skin. Skeletal hypoplasia affecting the cheek or chin area exacerbates the intrinsic loss of bone thickness and may have been present for life but has gone unrecognized until the patient begins to consider rejuvenation surgery. The position of the hyoid bone and larynx is variable. If in a low anterior position effacing the chin-neck angle, there will be a diminution of the surgical effect in this area regardless of platysmal suspension, submental liposuction, and cervical elevation (Fig. 6-2).

Aging caused by extrinsic factors such as sun exposure, smoking, and chronic dehydration of the skin are referred to as changes in substance. These may affect the epidermis, dermis, or subcutis. Extrinsic changes, which occur in the epidermis, include dysplasia and cytologic atypia with melanocyte hyperplasia and hypertrophy.² These abnormalities lead to pigmented irregularities of



FIGURE 6-1 Multiple signs of the aging process including intrinsic and extrinsic changes in the skin, skeletal atrophy, subcutaneous fat atrophy, and buccal and temporal fat atrophy.

the skin and variations in skin texture, and may subsequently deteriorate into cutaneous malignancies.

Extrinsic changes, which occur in the dermis, include elastosis, represented by thickening and tangling of the elastin fibers, and collagen degeneration with disorganization.³ There is also a decreased vasculature in the dermis, which can contribute to the pallor of older skin. In the subcutis, there is shortening of the trabecula of the retinaculum cutis, which occurs beneath the deep rhytids. This appears to be the result of repeated muscle

tone and contracture in these areas during the process of facial expression.

The manifestations of the intrinsic and extrinsic aging of the skin include the exacerbation of orthostatic wrinkles, the development and deepening of dynamic or coarse rhytids, and the development of fine, crepe-paper-appearing wrinkles.

Orthostatic skin creases generally represent physiologic excesses of skin present at birth such as those in the cervical region, the antecubital area, and the popliteal fossa. The deep rhytids generally become more visible due to the increase in skin laxity seen with aging, chronic folding of the skin through flexion or extension of the cervical vertebrae, and fluctuations in weight. Orthostatic rhytids are difficult to improve and may not respond to surgery (Fig. 6-3).

It is occasionally difficult to distinguish among dynamic, coarse, and fine wrinkles. It is generally thought that dynamic wrinkles do not disappear with stretching of the skin and are usually caused by the muscles of facial expression and the shortening of the retinaculum cutis. Dynamic rhytids would be represented by the furrows of the glabella and the crow's feet in the melolabial fold. This reflects the actions of the corrugators procures and orbicularis oculi muscle in the glabella area, the orbicularis oculi muscle in the lateral canthal region, and the zygomaticus major and minor, as well as the risorius and levator anguli oris in the melolabial fold and lateral oral commissure. The deep rhytids, which develop within the upper and lower lip, would reflect the action of the orbicularis oris muscle. Coarser dynamic rhytids usually require a skin tightening procedure, accompanied by resurfacing, or weakening of the muscles responsible for the overlying rhytids.



FIGURE 6-2 (A,B) Anatomic contributions to the aging process including microgenia, malar hypoplasia, and a low anterior hyoid.

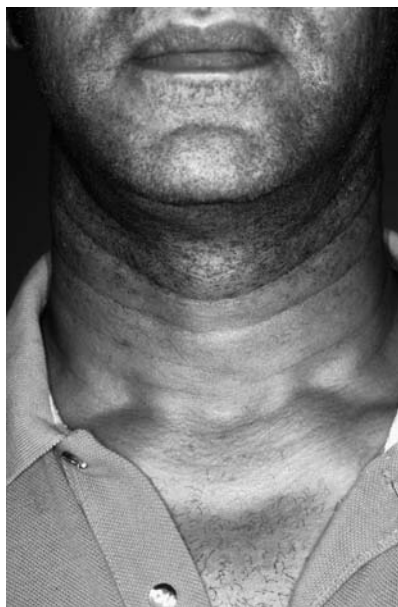


FIGURE 6-3 Orthostatic skin creases that cannot be eliminated with rhytidectomy.

The fine wrinkles that develop in the upper and lower eyelid and the buccal skin usually reflect intrinsic and extrinsic changes, which occur in the skin and disappear when the skin is stretched. These rhytids usually respond nicely to resurfacing.

Increased skin laxity or loss of resilience may contribute to the gravitational changes that occur, such as malar festoons, the undulating mandibular line, and platysmal banding, and can be corrected only with surgery.

CONSULTATION AND ANALYSIS

In this competitive cosmetic surgical market, the initial contact with the patient during the consultation is the best opportunity to instill confidence, educate the patient, and present yourself as a compassionate, competent, well-trained professional. Aging-face patients must be made to feel special, and that your only concern is their well-being. Interruptions must be avoided. Dedicated time to allow for uninterrupted patient consultation is essential.

During the consultation, it is good to have patients voice their concerns, perceptions, and expectations. This provides a foundation for assessment of their goals and evaluation of their motivation. Cosmetic surgery should not be done for someone else's goals, only the patient's. Realistic expectations must be emphasized and the margin of benefit for each patient evaluated. Patients must realize that a compromise is being made between the trauma of the surgery and the goal of rejuvenation.

A complete history must be taken including all medications with an emphasis on the presurgical elimination of all over-the-counter medications and nutritional supplements. The exact effect on blood coagulation of many nutritional supplements is not fully appreciated. Now that younger, active, and full-time employed people are seeking cosmetic surgery, an extensive social history is imperative so that patients may be better educated about the healing process and how it will affect their daily activities, so that adequate arrangements for postsurgical assistance can be made and the impact on their work responsibilities can be assessed. The surgical recommendations can provide a customized result that will be the least intrusive on the patient's lifestyle. As an example, someone who is unwilling or unable to avoid the sun after efforts at rejuvenation should not be offered resurfacing procedures but should be directed toward skin-tightening procedures such as a facelift or blepharoplasty. Most patients will do whatever is required for a smooth recovery if adequately educated about the reasons for avoiding overexertion, sun exposure, and premature return to work and social activities.

In addition to the specific questions that are relevant to the cosmetic surgical patient, a past medical history, review of systems, and general family and surgical history should also be taken, including questions regarding bleeding disorders and problems with anesthetics. Knowledge of a patient's previous surgical history can provide a surgeon insight into postsurgical complaints of nausea, pain, and discomfort. As a general rule, patients who have had previous surgery will not find surgery for facial rejuvenation particularly painful or unpleasant.

Physical examination should begin with an overall observation of facial expression and animation while discussing the patient's concerns. More specific evaluation of the skin type following Fitzpatrick's classifications should be recorded. The type of skin determines the postsurgical healing and may affect the decision-making process regarding incision placement and skin resurfacing recommendations. The degree of photodamage to the skin should also be noted. This may affect the choice of treatment regimens, especially the recommendation for regional versus global facial skin resurfacing.

Hair quality, texture, color, and density as well as pre-existing hairline positions are also relevant in educating the patient preoperatively about the technique and incision placement in forehead, brow, and facial rejuvenation. The degree of cervical banding and submental adiposity as it relates to hyoid position should be recognized. In patients with low anterior hyoid bones, the degree of impact on the cervical facial angle with liposuction and facelift surgery is markedly compromised. If this goes unrecognized and patients are not educated preoperatively, they will, more often than not, be disappointed with the postsurgical result.

In evaluation of the upper and lower eyelid, the degree of skin laxity, the degree of pseudoherniated fat, the symmetry in the position of both the upper and lower eyelid, muscular hypertrophy, the prominence of the globe itself within the orbit, asymmetries in the orbital rim, and the loss of tone within the lower eyelid should be recorded. These are all factors that will affect the postsurgical result and that need to be taken into consideration while planning a surgical approach. Male pattern baldness or a family history thereof may also affect the recommendations regarding surgical technique, especially when considering rejuvenation of the forehead and brow.

Lip height, contour, and fullness should be evaluated and noted including the presence or absence of perioral rhytids and thinning of the upper and lower lip. Ear position, size, and shape, and the relationship of the lobule to the face and neck should also be recognized and reported to the patient so that surgically the relationship between the lobule and the margin of the mandible can be reestablished. Many patients do not realize that their lobules are attached, or unattached, presurgically and may see them as different after surgery if this is not brought to their attention.

It is imperative to evaluate and educate the patients frankly about all their choices and surgical options so that they are empowered to make a well-informed decision. I would discourage trying to “sell” a procedure to patients even if it might offer a significant enhancement. Educating them so that they may make an informed decision to proceed or not proceed with a procedure they may not have considered previously is a much safer way to proceed.

During the first consultation, patients are provided with as much information as they are able to digest. Presurgical instructions are given to patients at this time even if they have not scheduled surgery so that they have an appreciation for the need to discontinue over-the-counter medications, aspirin-containing products, and herbal dietary supplements.

PHOTOGRAPHY

Photographic documentation is an integral and required part of facial plastic surgery. The photographs provide a means for evaluation and education that is unsurpassed. For these images to be of any value, they must be standardized as to framing, lighting, and patient position. Every bit as important in obtaining useful photographs as the parameters just described but much less controllable are the patient's hairstyle, makeup, and jewelry. To gain this standardization in the initial phases of a practice, it is best for surgeons to take their own photographs and learn the techniques they wish to utilize. Once a pattern has been established and a reliable employee with an interest in photography is

trained in this pattern, these responsibilities may be delegated. But the surgeon must maintain constant supervision, because the photographs must satisfy the surgeon's need for exacting detail.

The gold standard is 35-mm photography. The resolution of digital photography has continued to progress, exceeding the ability of printers to reproduce the image with the same detail with which it was originally recorded. Without a doubt, archiving and retrieving of photographs is much easier with digital photography. The main drawback with digital photography is the initial expense.

Techniques for standardized photodocumentation have been laid out very well by several authors.^{4,5} The parameters are provided here simply as a guideline, as are the recommendations that I have found useful in simplifying my efforts to obtain standardized photography. Efforts should be made with photography to include all areas of interest while minimizing the amount of background. It is easiest to obtain this result most consistently using a 105-mm macrolens on a setting of 1 m for full face and neck photographs including rhinoplasty pictures and on 1.5 m for regional facial photographs. The F stops that provide the best exposure at these settings are 11 and 16, respectively. The camera is used on manual exposure and focus to control the parameters. When using the automatic setting, the camera has a tendency to choose a lower F stop, resulting in a shorter depth of field.

Photographs are taken at 90 degrees, 45 degrees, and 0 degrees off the sagittal plane for all patients. Full-face photographs are taken with the camera oriented in the vertical position, whereas segmental photographs are taken with the camera oriented horizontally.

Frequently, the most difficult thing to reproduce is patient head and eye position. Especially with blepharoplasty, eye position can affect the overall perception of the result. I have been able to best obtain reproducible angle, head position, and eye position by placing targets at 90 and 45 degrees from the patient's chair. This guarantees that if the patient focuses on these targets, the eyes will be in the same position. The chin certainly must be adjusted to align the Frankfort plane.

Two sets of preoperative photographs are taken of every patient for teaching purposes. This provides a set of photographs that can be used to introduce the patient to the audience and another set of preoperative photographs to compare with the postoperative results.

Digital photography has progressed to the point where a through-the-lens viewfinder is now available where standard focal distances can be set manually and where flash lighting can be utilized. With these improvements and digital photography, I would anticipate that within a matter of a few short years, standard 35-mm photography will be a matter of personal preference rather than a choice because of better quality.

ANESTHESIA

Regardless of whether these surgical services are provided in a hospital setting, an ambulatory surgical center or office-based surgery center, the decision making for anesthesia should not vary. Primarily it is based on the health status of the patient; subsequent to that, patient preference, anxiety level, and the skill of the anesthesiologist or the anesthetist must all be considered. Quality of care and safety outweigh any other factors under consideration. Procedures can be performed under straight local anesthesia, oral sedation with local anesthesia, monitored anesthesia care, and general anesthesia with airway intubation. The guideline in my practice is that any procedure that may take longer than 2 hours is done with a general anesthetic. I have not found topical anesthesia useful for laser resurfacing of any kind.

The advantage that makes general anesthesia my preference in the office-based surgery center is control. With a well-trained anesthetist or anesthesiologist and the medications that are presently available, the risk of general anesthesia is as low or lower than monitored anesthesia care. Complete control of the patient's airway once it is intubated provides the security that is needed for longer procedures and the airway control that may be needed for rhinoplasty. Having confidence in the skill of the endoscopist who will place the endotracheal tube is imperative. The tube should certainly be insinuated rather than forced between the vocal cords. If these parameters for intubation are followed, then the risk of dental injury or laryngeal injury are minimal and the security provided is unparalleled.

For patients who are undergoing relatively minor procedures such as scar revision, skin flap, repair of soft tissue defects, isolated upper or lower lid blepharoplasty, and isolated chin augmentation, these procedures are usually done under oral sedation and infiltration anesthesia. The infiltration of choice is 1% lidocaine and 1:100,000 epinephrine. When a regional nerve block would be useful in completing the procedures, it is performed prior to the time of infiltration. The guidelines for the volume of local anesthesia to be infiltrated when using plain lidocaine or lidocaine with epinephrine are followed.

When more extensive procedures are contemplated and monitored anesthesia care or general anesthesia are necessary, the patients are generally not sedated prior to arriving at the office so that completion of their presurgical consultation with the anesthesiologist or anesthetist can be done in a completely alert fashion. All these patients receive a call from the anesthesiologist within 36 hours prior to their surgery in which a complete anesthesia history is taken over the phone.

When procedures are being done that require more than 15 cc of local infiltration, then 0.5% lidocaine and 1:200,000 epinephrine is used. When multiple surgical procedures are being performed at the same time,

regional infiltration is maintained throughout the execution of the procedure, trying to avoid reaching a toxic level of infiltrate while optimizing the vasoconstrictive effect of the epinephrine.

In the development of an office-based surgery center, special consideration needs to be given to the level of anesthesia to be utilized. Regulations vary from state to state and in some instances are quite restrictive regarding requirements for monitoring medications, the level of anesthesia that can be performed, and the personnel required in the operating room and recovery area. Before investing significant money in developing an in-office operating suite, these issues should be investigated. If office space can be obtained in a building that houses an ambulatory surgery center, this is an ideal situation, reducing the initial cost of developing a cosmetic surgery practice but maintaining the convenience of an office-based surgery center.

It is important to keep the agents used for infiltration as uncomplicated as possible. Seldom, if ever, is custom mixing of multiple solutions performed because it increases the possibility of error. Certainly, the supplementation of lidocaine with a longer acting anesthetic has been found useful by many physicians and is beneficial in reducing the acute postoperative pain. This may expedite patient discharge but results in an increased number of telephone calls from the patient after discharge because of unmanaged pain.

PROCEDURES

REJUVENATION OF THE FOREHEAD AND BROW

As new options become available for rejuvenation of the forehead and brow, from endoscopic browlift to percutaneous brow suspension, the recommendations and decision making become more complex. Formerly, forehead and brow rejuvenation was a procedure with choices dictated more by personal preference than by the specific anatomic and cosmetic needs of the patient. But now it is a procedure with more specific indications for each technique, necessitating more detailed evaluation.

It is important to emphasize that almost all patients who present for blepharoplasty consultation should be evaluated for the appropriateness and integration of forehead rejuvenation into their management. Most patients do not consider the brow or forehead to be part of the pathology affecting the upper eyelid and creating a tired, more-haggard appearance. With education of the patient regarding the impact of brow position on the appearance of the upper eye and the ability of upper eyelid blepharoplasty to rejuvenate the eye, most will be accepting of the concept and not offended by the recommendation. The importance of having a necessary browlift precede upper lid blepharoplasty has been

reiterated in numerous studies, whether it precedes the blepharoplasty by hours, weeks, months, or years.

When forehead rejuvenation and browlift is considered, the surgeon and patient must take into account features that would lead to the best result with the least apparent scars and postoperative sequelae. When considering the type of browlift to perform, it is important to assess the texture and quality of the hair, the position of the hairline, the status of the forehead skin, the degree of brow ptosis, and the patient's dominant hairstyle. The lifestyle must be considered with respect to outdoor activities such as swimming and cycling, which might cause highlighting of an exposed scar. All these features affect the choice made and the direction that the surgeon should lead the patient in while making a decision.

The ideal brow position and contour continues to be debated. I think a consensus has formed consistent with Cook et al's⁶ recommendations (Fig. 6-4) that a more natural and less startled appearance is obtained when the arch of the brow is positioned along a vertical plane that is even with the lateral canthus of the eye. It has been recommended that the height of the arch be positioned at the lateral limbus (Fig. 6-5) occasionally led to a startled look. The actual height of the brow may be considered ptotic if it is less than 26 to 28 mm above the midpupil. Westmore has suggested that the ideal position of the lower border of the brow be equal to twice the distance of the palpebral aperture from the lower eyelid margin. These specific recommendations should be taken into consideration when determining the ideal brow position with respect to the aesthetics of the patient as well as the contour of the brow at a younger age. Marked change in the contour of the brow beyond its elevation may be unsatisfactory for the patient.

Patients with a low frontal hairline are best managed with either a coronal or endoscopic browlift (Fig. 6-6). Both these lifts reposition the frontal hairline more superiorly. The distinction between endoscopic browlift and



FIGURE 6-5 Positioning of the arch of the brow at the lateral limbus may lead to a more startled appearance.



FIGURE 6-6 Ideal candidate for endoscopic brow lift with low frontal hairline.



FIGURE 6-4 Arch of the brow positioned along a vertical plane at the lateral canthus as recommended by Cook.

coronal browlift is based on hair quality and texture and the functional degree of ptosis. In a patient whose brow ptosis creates a functional problem with the upper eyelid and peripheral vision, the recommendation should be for coronal browlift where the more time-tested technique with the excision of scalp provides a more predictable duration to the brow elevation. The full coronal lift is better tolerated in people with thin, salt-and-pepper hair. If any alopecia at the incision does develop, then the contrast between the bald incision and the hair-bearing scalp is minimal and imperceptible in most cases. For patients with brow ptosis that does not present a functional problem, and for patients with darker, thicker hair, endoscopic browlift is preferred. If any alopecia does

develop, it is separated from adjacent incisions. Generally, endoscopic lift incisions are directed parallel to natural parts in the hair and can be easily camouflaged. Endoscopic browlift is indeed a technique that can yield dramatic brow elevation, but further studies are needed to determine whether it will stand the test of time as the coronal lift has.

For patients with a high frontal hairline, there are two surgical approaches I find acceptable: the trichophytic incision within the frontal hairline and the midforehead approach. The choice may depend on hairstyle but more importantly on the depth of the forehead rhytids.

The trichophytic browlift is performed with a broken-line incision following the random pattern of the frontal hairline (Fig. 6-7). The incision is beveled inferiorly so that any random hairs that may be growing outside of the hairline will have the opportunity to regrow through the incision by amputation and preservation of the follicle. The amount of elevation is measured and the amount of skin to be excised is predetermined and marked. This is the best way to guarantee the pattern interdigitation after excision.

For patients with a high frontal hairline or a receding hairline and deep midforehead rhytids, a midforehead browlift is performed with excision of one or more forehead rhytids (Fig. 6-8). This incision is best interrupted at the midline or paramedian position depending on



FIGURE 6-7 Broken-line trichophytic incision for patients with a high temporal and frontal hairline.



A



B,C



FIGURE 6-8 (A) Midforehead incision for patients with high frontal hairline and deep forehead rhytids. (B) Preoperative. (C) One-year postoperative.

personal preference. The third option available for patients with a high frontal hairline or male pattern baldness is a direct browlift. This procedure is most useful in facial paralysis patients where specific sculpting of the brow is necessary to match the opposite side and where a scar at the upper edge of the brow, which may be perceptible, is less of a distraction. Otherwise, the direct lift is seldom used.

Other approaches to browlift include a midforehead extension of a trichophytic facelift incision or lateral brow elevation with an incision within the temporal tuft of hair (Fig. 6–9). These procedures are usually applied when only lateral elevation is necessary, and have been done when inadequate lateral brow elevation has been obtained with coronal, endoscopic, or a trichophytic lift.

Anatomy

The anatomy of the scalp and forehead is extremely consistent and uncomplicated. The layers of the forehead reflect the anatomy at the scalp, with the galea aponeurosis reflecting the connective tissue capsule over the frontalis muscle. The galea then extends posteriorly and superiorly to connect with the occipitalis posteriorly. The supratrochlear and supraorbital nerves provide the sensory innervation of the forehead and anterior scalp. The supraorbital nerve is routinely found at a level along the superior orbital rim even with the pupil. The supraorbital nerve may or may not exit through a foramen. Most frequently it exits the orbit through a notch at the orbital rim, which can be palpated through the skin. In some patients the nerve exits directly through a foramen, and for this reason, if no notch is palpated in the orbital rim, endoscopic visualization should be maintained while dissecting in the supraorbital area to prevent trauma or avulsion of the supraorbital nerve. The supratrochlear nerve exits the orbit medially ~2 cm from the midline and traverses the corrugator muscle prior to reaching the deep surface of the frontalis and penetrating it. The supraorbital nerve may penetrate the

frontalis immediately to run on the superficial surface of the frontalis muscle, or it may penetrate at varying heights up above the brow, and this is why care must be taken when the frontalis is divided beneath the deep forehead rhytids.

The temporalis muscle is bounded anteriorly and superiorly by the superior temporal ridge (Fig. 6–10). Beneath the subcutaneous tissue is the temporoparietal fascia, which is analogous to the superficial layer of the deep temporal fascia. This fascia is consistent with the periosteum over the frontal bone at the superior temporal line. Within the temporoparietal fascia lies the frontal branch of the facial nerve as it courses across the midzygomatic arch and extends superiorly in the temporoparietal fascia toward the deep surface of the frontalis muscle. The frontalis muscle acts to elevate the brow and has its origin in the fascia of the orbicularis oculi muscle. The remaining periorbital muscles, including the paired corrugator supercilii, procerus, and orbicularis oculi muscle, act as brow depressors.

The periosteum over the frontal bones extends inferiorly and becomes continuous with the periorbita at the arcus marginalis. When subperiosteal elevation is performed with endoscopic, trichophytic, or coronal browlift, it is imperative that the arcus marginalis be divided to allow mobilization of the brow superiorly.

There are several general rules that apply to browlift and elevation. The more remote the incision for a browlift, the larger the amount of tissue that must be resected. As described by Ferdinand Becker, an excellent rule of thumb is two times the desired brow elevation for a coronal lift, $1\frac{1}{2}$ to two times the desired elevation for a trichophytic lift, and $1\frac{1}{2}$ times the desired elevation for a midforehead lift. In addition, the more remote the incision, the deeper the plane of elevation. For a coronal or endoscopic lift, the plane of elevation is generally subgaleal or subperiosteal. Because of the shear between the galea and the periosteum, I have found that subgaleal elevation provides a better mobilization and long-term result.

The trichophytic incision (Fig. 6–11) is also accompanied by an endoscopic subgaleal elevation following subcutaneous skin excision. Because of the adherence of the galea to the periosteum and the supraorbital and glabellar areas, frequently it is necessary to elevate a subperiosteal plane from ~2 cm above the orbital rim, inferiorly dividing the periosteum and the arcus marginalis at the orbital rim (Fig. 6–12). The periosteum, if elevated inferiorly, must be divided centrally so that the corrugator and procerus muscles can be identified and avulsed. If care is not taken, multiple planes can be violated in the glabella and supraorbital areas, creating confusion and disrupting visibility. When attempting to remain subgaleal for the entire elevation, visualization during elevation is necessary. Subperiosteal elevation can be done to just above the orbital rim without visualization.



FIGURE 6–9 Lateral temporal lift with partial midforehead and trichophytic temporal incision.

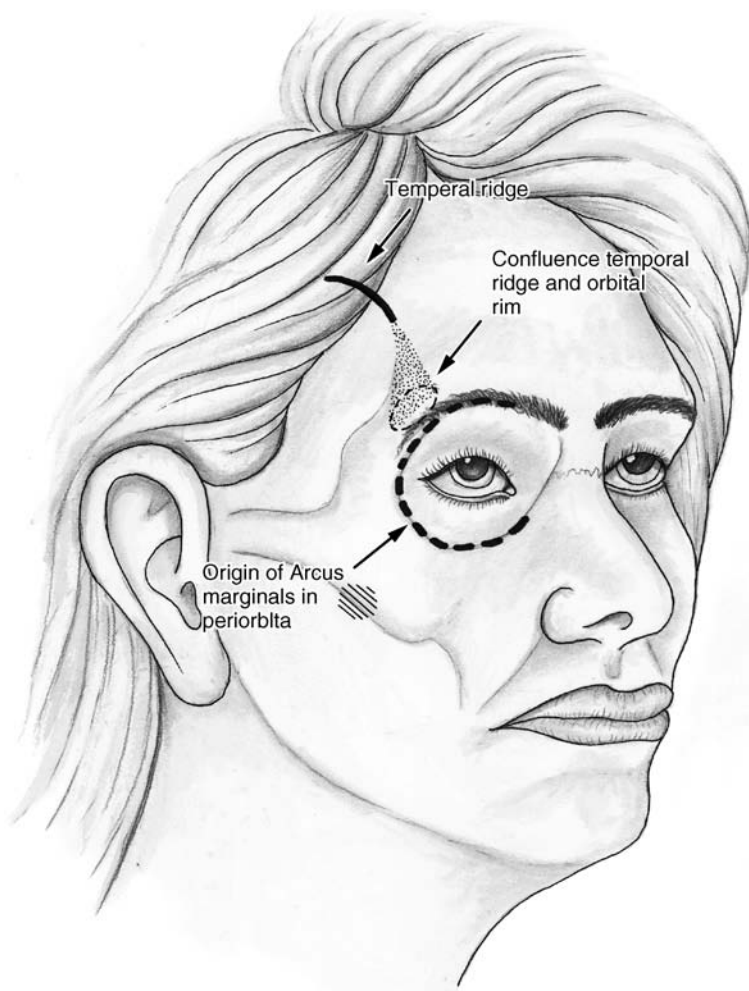


FIGURE 6-10 The interdigitated temporoparietal fascia and the periosteum at the inferior portion of the temporal ridge adjacent to the orbital rim are extensive and require meticulous dissection to assure release at this point.

Midforehead, temporal, and direct browlifts are elevated in a subcutaneous plane. This elevation extends down to the superior margin of the brow, occasionally encountering follicles of the brow. Centrally, the subcutaneous tissue and frontalis muscle are divided so that the corrugator and procerus can again be avulsed. After this is performed, the orbicularis oculi muscle at the superior margin of the brow is suspended to the periosteum with interrupted Maxon sutures at positions on the brow that are even with the medial limbus, lateral limbus, and lateral canthus. After orbicularis oculi muscle suspension is completed, these skin flaps are redraped and marked, and redundant skin is excised. Hemostasis is always obtained with bipolar electrocautery, and care is taken not to injure the supraorbital nerve with the suspension suture.

With coronal, trichophytic, and endoscopic browlift, more extensive lateral elevation is performed. The temporalis fascia is identified and the temporoparietal fascia or superficial layer of the deep temporal fascia is elevated. This elevation extends into the temporal fat down to the zygomatic arch and malar eminence. The periosteum is

incised and periosteum elevated off the malar eminence and zygomatic arch. Prior to incision of the periosteum of the malar eminence, the sentinel vein is identified, which is usually present at the level of the lateral canthus 1 cm lateral to the orbital rim. Care is taken to preserve this vein because it is found adjacent to the frontal branch of the facial nerve superficially within the temporoparietal fascia. Frontalis muscle may be divided beneath the deep forehead rhytids with care taken to avoid the supraorbital nerve.

Suspension of the brow is obtained through scalp or forehead skin excision with the coronal or trichophytic browlift, respectively. With an endoscopic browlift, suspension must be obtained with complete subgaleal elevation over the vertex and occiput as well as laterally at the superior and posterior temporal ridge (Figs. 6-10 and 6-12). After complete elevation is accomplished, suspension can be obtained with monocortical screws, which may be titanium or absorbable, or with suture suspension to a bone bridge. With screw fixation, titanium screws may be left in place or removed. These screws have been used percutaneously, which expedites removal

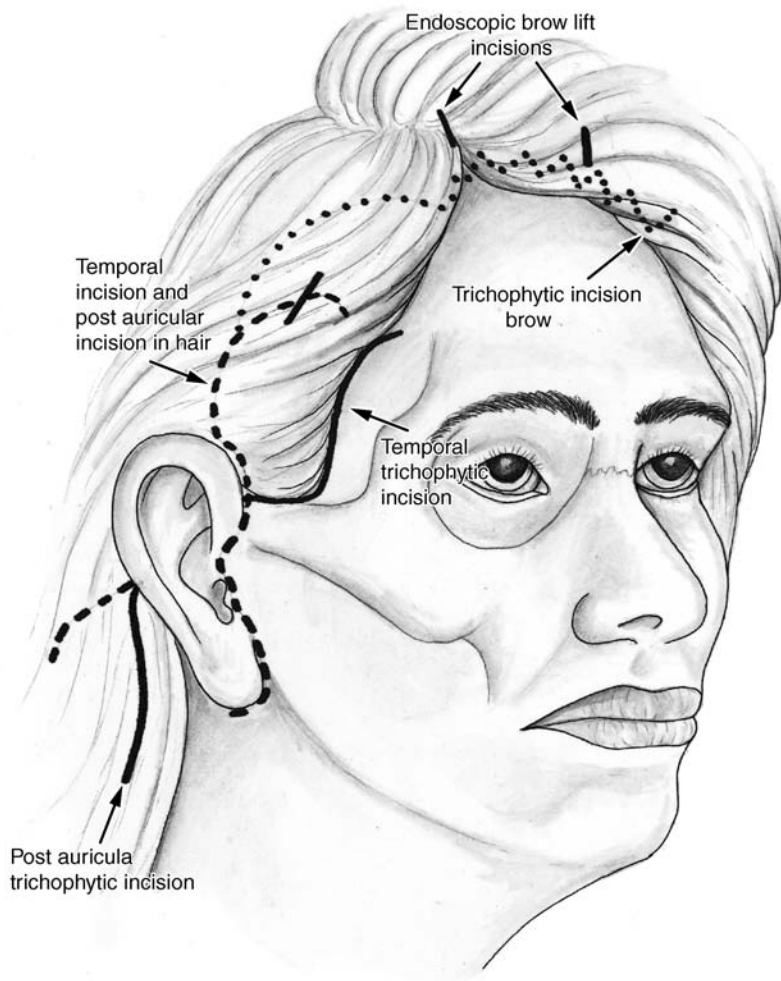


FIGURE 6-11 Incision sites for approaches to the brow and face. With a low or intermediate frontal hairline position, endoscopic or coronal decisions can be made for the browlift. With a high frontal hairline, a trichophytic incision is usually made. Hairline position also determines placement of the temporal portion of the facelift incision. The position of the postauricular hair incision is determined by the degree of cervical skin laxity; if minimal laxity is present, the decision is extended into the hair. When extensive cervical laxity is present, the incision is made in a trichophytic fashion.

at 3 weeks. With these procedures, complete release of the arcus marginalis lateral to the supraorbital nerves is essential.

The most tedious part of these dissections is release of the arcus marginalis and galeal-periosteal complex at the junction of the superior orbital rim and the superior temporal line (Fig. 6-12). This is the point where the frontal branch of the facial nerve is most vulnerable. Careful blunt and sharp dissection is used most often proceeding from the posterior flap beneath the temporoparietal fascia, which interdigitates with the periosteum at the temporal line through a conjoint tendon (Fig. 6-12). All browlifts are accompanied by a dressing for 24 hours.

Complications

Complications from brow and forehead rejuvenation include alopecia, numbness, bleeding, infection, frontal nerve paralysis, and paresthesias. The subcutaneous forms of the procedure such as the midforehead, direct, and temporal incisions are less likely to be accompanied by numbness and should not cause alopecia.

The trichophytic and coronal lift cause acute postoperative numbness, which may resolve. Patients are informed that this numbness will occur in the acute postoperative period and that it may not resolve, so that if resolution does not occur they are not disappointed. The endoscopic brow and forehead lift can be accompanied by numbness, but it is much less likely to occur and it should completely resolve.

Occasional paresthesias and phantom sensations can occur posterior to the coronal or trichophytic incisions.

BLEPHAROPLASTY

Rejuvenation of the eyelids is the first procedure considered by most patients. The limited nature of the surgery, the short recovery period, and the obviously evident early deterioration of lid skin make blepharoplasty an easy choice as a first cosmetic procedure. A review of the medical-surgical history involving the eye focus on glaucoma, dry eye syndrome, or corneal surgery. During the physical exam, contributing factors such as brow ptosis, lacrimal ptosis, and ptotic fat that might contribute

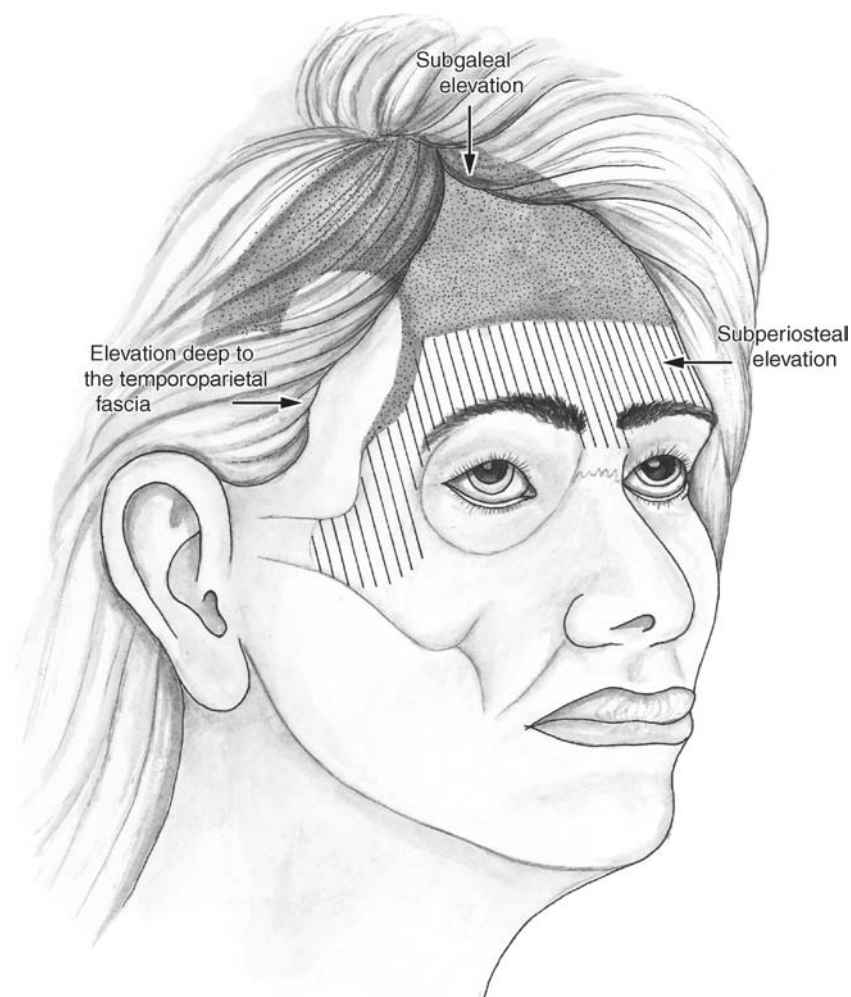


FIGURE 6-12 The planes of elevation for browlifting are consistent with an initial subgaleal elevation over the superior forehead and a subperiosteal elevation initiated 2 cm above the orbital rim. Lateral elevation is to the temporoparietal fascia on the true temporal fascia. For a mid-forehead browlift the elevation is in a deep subcutaneous plane.

to an unsatisfactory result must be evaluated. The degree of lower lid laxity must be assessed. If the lid can be retracted more than a centimeter away from the globe or does not snap back adjacent to the globe immediately upon its release, some form of resuspension should be considered.

Discussion of blepharoplasty requires clarifying the terminology used to describe abnormalities of the upper and lower eyelid. Variations of two distinct conditions may be present. The senile changes that occur in the upper and lower eyelid include dermatochalasis, which reflects relaxation of the skin accompanied by varying amounts of fat pseudoherniation or prolapse (Fig. 6-13). In contrast, blepharochalasis is an infrequent disorder in young people associated with swelling and edema of the lids with progressive tissue breakdown, which leads to prolapse of the orbital fat and possibly the lacrimal gland (Fig. 6-14).

Orbital anatomy is integrally related to the deformity appreciated at the time of examination and should be taken into consideration during surgical planning and execution to achieve the most ideal result and to



FIGURE 6-13 Patient with dermatochalasis of the upper and lower eyelid with senile pseudoherniation of fat from the lower eyelid.

prevent complications. The bony orbit is composed of contributions from the frontal, zygomatic, maxillary, sphenoid, palatine, lacrimal, and ethmoid bones. The size of the orbit and the position of the orbital rim may



FIGURE 6-14 Blepharochalasis exaggerated on upward gaze in a patient with congenital edema.

vary from one side to the other and should be noted preoperatively.

The lids themselves are composed of skin, subcutaneous tissue, three muscles (orbicularis, Müller's, and levator), and varying degrees of fat, tarsus, and conjunctiva. The lid crease or palpebral fold is created by the insertion of the levator aponeurosis and the orbital septum into the orbicularis oculi muscle at the upper edge of the tarsal plate. In the occidental upper eyelid the levator aponeurosis inserts along the tarsal plate with few distinct connections to the orbicularis and skin.

Skin beneath the palpebral crease, the pretarsal skin, is usually very thin and has a varying degree of mobility. The skin, subcutaneous tissue, and preseptal orbicularis oculi muscle above the lid crease contribute to the lid fold.

The orbicularis oculi muscle includes a pretarsal, preseptal, and orbital components. The pretarsal orbicularis oculi muscle fused to form the medial canthal tendon

attached to the anterior lacrimal crest superiorly and the posterior crest inferiorly. The preseptal portion of the orbicularis oculi muscle is the portion that is most frequently modified with upper lid blepharoplasty. It is important with lower lid blepharoplasty to preserve the pretarsal orbicularis oculi muscle as completely as possible. The orbital portion of the orbicularis oculi muscle superiorly contributes to the fullness and thickness of the skin beneath the brow and is better addressed with brow elevation. Deep to the orbicularis oculi muscle is the tarsal plate and orbital septum. The septum is a continuation of the periorbita and arcus marginalis to the peripheral margin of the tarsal plate of the upper or lower eyelid. It may weaken with age, resulting in a pseudoherniation of fat.

The tarsal plate is a fibrous plate about 8 to 10 mm wide in the upper lid and 3 to 5 mm wide in the lower lid. It extends from the lateral canthal tendon to the medial canthal tendon and punctum and is lined on its deep surface by conjunctiva.

Upper Lid Blepharoplasty

Upper lid blepharoplasty may need to address skin laxity, thickened orbicularis oculi muscle, or possibly herniation of the medial and central fat compartments. Ptosis of the lacrimal gland can also be corrected if recognized.

The technique for upper lid blepharoplasty may include the predetermination of the skin to be excised or elevation of a flap with excision of redundant skin at the time of surgery.

With the patient in the upright position prior to infiltration with anesthesia, the upper eyelid is marked at the tarsal crease or palpebral fold usually extending lateral to the lateral canthus for ~1.5 cm. After the tarsal crease is marked, the lid is pinched and the amount of skin to be excised is predetermined and marked (Fig. 6-15). If orbicularis hypertrophy is appreciated, then the pretarsal orbicularis muscle is resected in conjunction with the skin. After resection of the upper eyelid skin and muscle,



FIGURE 6-15 Marking for upper lid blepharoplasty with the patient in the upright position. (A) The inferior incision is in the palpebral crease. (B) Determining the resected amount with the head in a neutral position and eyes closed to avoid over-resection.

the orbital septum is divided medially and centrally with the resection of herniating fat. Protruding fat is first cross-clamped with a hemostat, resected, and the stump of the fat cauterized with bipolar electrocautery (Fig. 6–16). This can be performed with a CO₂ laser if desired.

If the only pathology of the upper eyelid is excess skin, then the skin is trimmed and the wound is closed with a running subcuticular nylon suture.

Lower Lid Blepharoplasty

In lower eyelid blepharoplasty there are more options available to address the specific pathologic changes that might be present from simple dermatochalasis to lid laxity, festoons, and ectropion. The surgical procedure is customized to deal with the pathology present and optimize the results.

The decision is based not only on the degree of dermatochalasis but also on the degree of orbicularis hypertrophy, the amount of pseudoherniation of fat, the tone in the lower eyelid, and the patient's personal preferences. If dermatochalasis is the primary pathology to be addressed, then a skin muscle flap or laser resurfacing of the lower eyelid would be the primary treatment choice (Fig. 6–17A). For patients with extensive pseudoherniation of fat as well as dermatochalasis, a skin muscle flap with fat excision or transconjunctival blepharoplasty with laser resurfacing is the primary

recommendation (Fig. 6–17B). For patients with a subciliary ridge due to orbicularis hypertrophy, a skin muscle flap with trimming of the orbicularis oculi muscle and skin excision with orbicularis resuspension provides the optimal result. Of patients in the first two categories where laser resurfacing might be considered, if the patient's lifestyle necessitates an early return to function, then the surgical approach with skin excision is the method of choice. If, however, the patient has the need to address facial or perioral rhytids and laser resurfacing is to be used elsewhere on the face, then the transconjunctival approach with fat excision and laser resurfacing of the eyelid is performed. A transconjunctival blepharoplasty with the pinch technique and excision of lower lid skin is also an option that does not disrupt the pretarsal orbicularis muscle.

Maintaining the continuity of the pretarsal orbicularis muscle is important in avoiding the most common postoperative complication of ectropion. Special modifications of the skin muscle flap are made to try to preserve the pretarsal orbicularis.

In performing upper and lower blepharoplasty with skin excision or with laser resurfacing, it is extremely useful to place a tarsorrhaphy suture at the midpupillary line to stabilize the lids, provide improved retraction, protect the cornea, and prevent excess skin resection. When transconjunctival blepharoplasty is being done in conjunction with upper lid blepharoplasty,

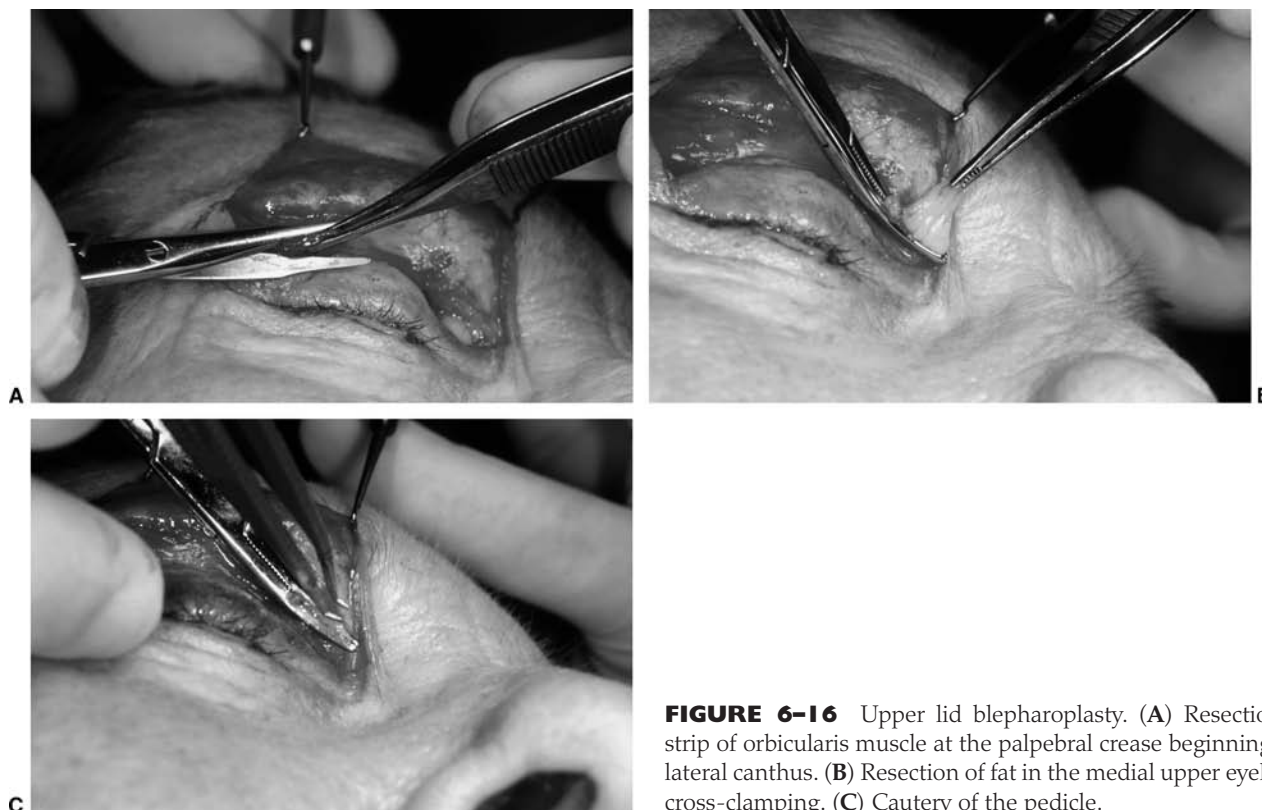


FIGURE 6–16 Upper lid blepharoplasty. (A) Resection of a strip of orbicularis muscle at the palpebral crease beginning at the lateral canthus. (B) Resection of fat in the medial upper eyelid with cross-clamping. (C) Cautery of the pedicle.



FIGURE 6-17 The appropriate lower lid blepharoplasty is determined based on certain physical and anatomic features. (A) Patient appropriate for lower lid blepharoplasty with various techniques including transconjunctival fat excision and pinch techniques, laser resurfacing or a skin muscle flap. (B) Pseudoherniation of fat with minimal to no dermatochalasis in an excellent candidate for transconjunctival blepharoplasty. (C) Dermatochalasis and pseudoherniation of fat with loss of tone in the lower eyelid requiring skin and fat excision with suspension of the lower eyelid. (D) Moderate dermatochalasis with extensive midface ptosis, deep nasal jugal groove, good lower eyelid tone, and pseudoherniated fat representing an ideal candidate for a suborbicularis oculi fat (SOOF) lift.

the transconjunctival fat excision is performed first, and then the tarsorrhaphy sutures are secured to protect the globe during laser resurfacing and to stabilize the upper lid for incision and excision of skin.

Transconjunctival blepharoplasty is performed in the patient who has a primary pathology of fat protrusion and minimal to no dermatochalasia (Fig. 6-18).

The lower eyelid is infiltrated with 1% lidocaine and 1:100,000 epinephrine including an infraorbital nerve block and conjunctival infiltration. When this is done under local anesthesia, it is helpful to anesthetize the conjunctiva with a topical ophthalmic anesthetic agent. After anesthesia is obtained, the Yaeger plate is used to place pressure on the globe and an insulated Desmarres retractor used to retract the lower eyelid. The inferior orbital rim is palpated and a fine-tip electrocautery needle is used (Fig. 6-18A). An open sky incision is made through the conjunctiva from central to lateral. This is performed down to the orbital rim without incision in the periosteum of the orbital rim. At this point, the fat frequently herniates and is apparent in the wound. If

portions of the orbital septum persist, bipolar electrocautery is used to divide the vasculature within the septum, and it can then be further separated using electrocautery or tenotomy scissors.

Immediately after incision of the conjunctiva, the conjunctiva is sutured with a draw suture of 3-0 silk to protect the globe superiorly. This is stabilized through the head dressing with a hemostat. After the conjunctiva is stabilized superiorly over the globe, medial, central, and lateral fat compartments are identified; herniating fat is cross-clamped with a hemostat and the fat excised. Once fat excision is completed, the base of the herniating fat is cauterized with bipolar electrocautery. The hemostat is then gradually released and maintained in place to act as a retractor of the adjacent soft tissues, and the visible portion of the stump is again cauterized. The central and lateral fat compartments are then addressed in the same way. In the central fat compartment, it is important not to dissect into the orbit without identification of the inferior oblique muscle. If fat herniation occurs anterior to the orbital rim, then it is not

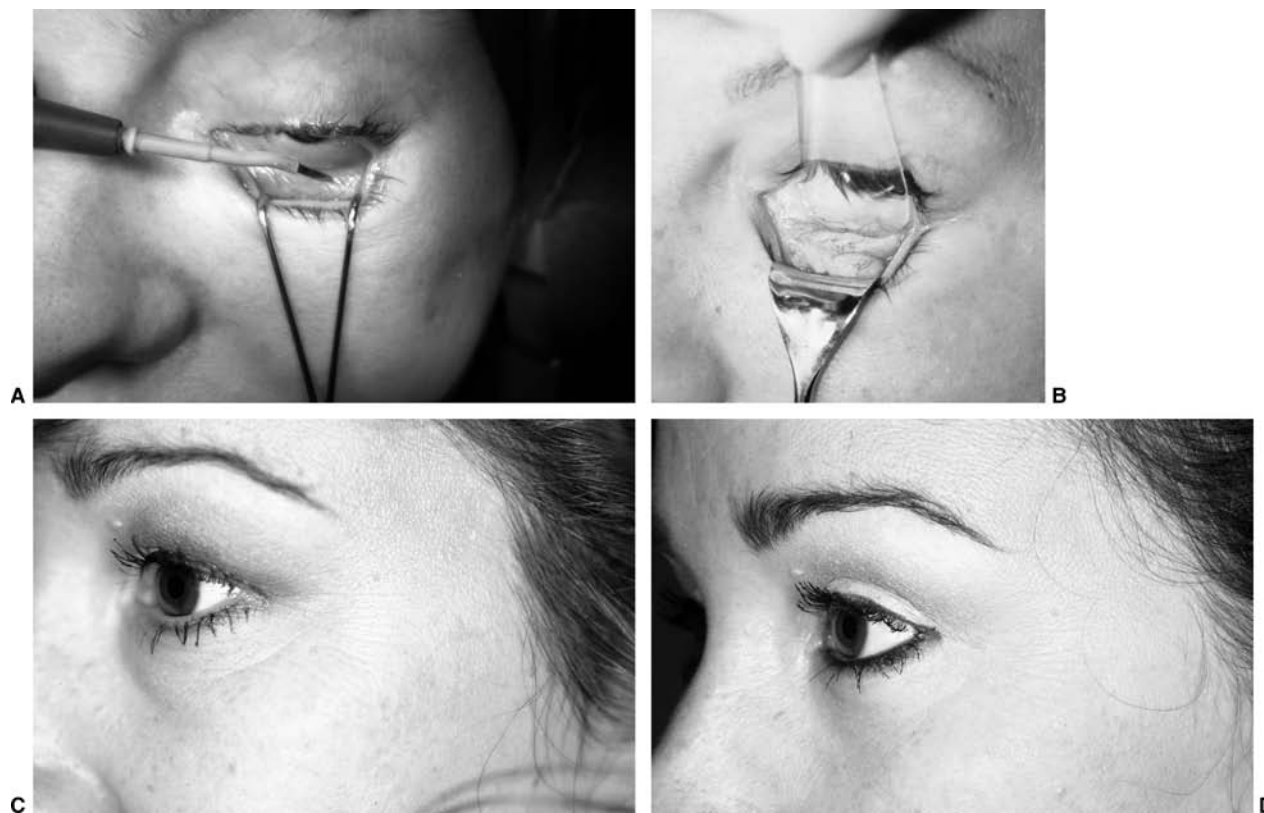


FIGURE 6-18 Transconjunctival blepharoplasty. (A) Lid retraction and sub tarsal transconjunctival incision. (B) Lid retraction and global pressure with a Yeager plate creating herniation of orbital fat. (C) Preoperative. (D) One year postoperative.

imperative to identify the inferior oblique muscle. The lateral fat compartment is sometimes the most difficult to identify and to resect the fat from during a transconjunctival blepharoplasty. Once the surgeon believes that adequate fat has been resected, the lower lid is released and repositioned over the globe. Pressure on the orbit will reveal any residual fat that might represent a problem postoperatively. This segment may then be read-dressed if necessary (Fig. 6-18C,D).

When excessive dermatochalasis is apparent and the transconjunctival approach is chosen for fat excision and with laser resurfacing to address the dermatochalasis, the tarsorrhaphy suture is placed after excision of the lower eyelid fat. After the tarsorrhaphy suture is secured, excessive upper eyelid skin is resected and the upper eyelid completed. Laser resurfacing is then performed with vaporization of the deep rhytids that had been marked prior to surgery. After the deep rhytids have their margins vaporized, the entire lid is resurfaced in two passes while tapering at the margin of each pass.

When an incisional approach is made (Fig. 6-19) for lower eyelid blepharoplasty, a subciliary incision is made 2 to 3 mm beneath the lash margin, maintaining an isthmus at the lateral canthus of 6 to 7 mm between the lower and upper eyelid incision and extending $\sim 1\frac{1}{2}$ cm in an inferior lateral direction from the lateral

canthus following a natural skin crease (Fig. 6-20A). This usually brings the lateral extent of the lower eyelid incision immediately over the lateral portion of the lateral rim.

When a moderate degree of dermatochalasis or orbicularis hypertrophy is encountered and a skin muscle flap is the technique to be used, tenotomy scissors are inserted with division of the orbicularis oculi muscle beneath the lateral extent of the skin incision. Suborbicularis elevation is then performed bluntly with the tenotomy scissors over the orbital rim. At this point, one blade of the tenotomy scissors can be inserted into the suborbicularis pocket (Fig. 6-20B) inferiorly with the other blade maintained at the subciliary incision. It is then easy to maintain a preseptal elevation of the orbicularis oculi muscle by incrementally advancing and closing the scissors, maintaining the superior blade of the scissors beneath the lashes in the subciliary incision. The scissors are beveled inferiorly to preserve the preseptal orbicularis oculi muscle. After the incision is completed, any persistent connections between the orbital septum and orbicularis muscle are divided. Hemostasis is obtained at this point with electrocautery.

The skin muscle flap is then retracted inferiorly. Medial, central, and lateral fat compartments are addressed as

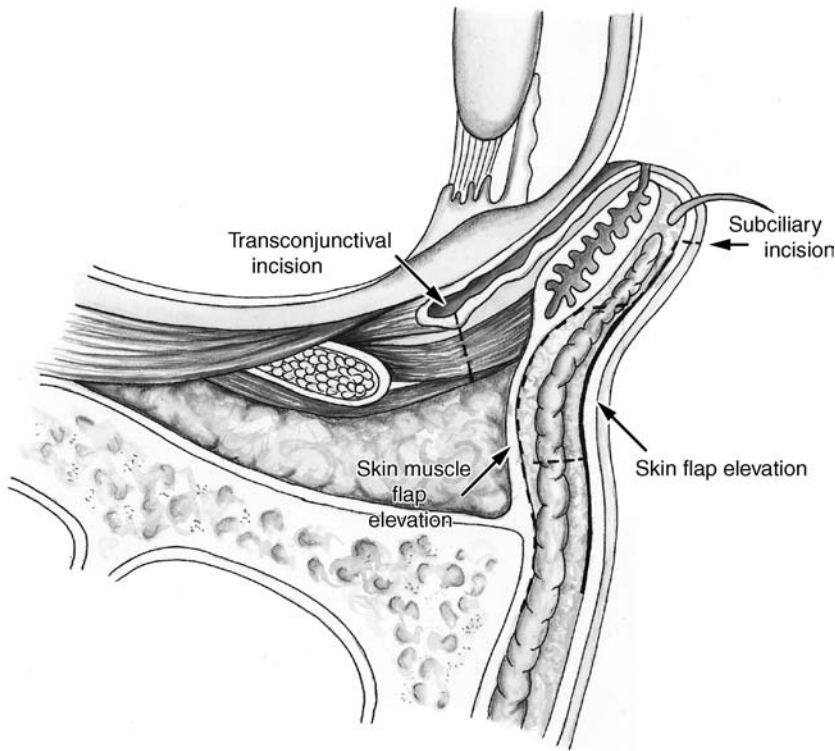


FIGURE 6-19 Incisions for approaches in lower lid blepharoplasty.

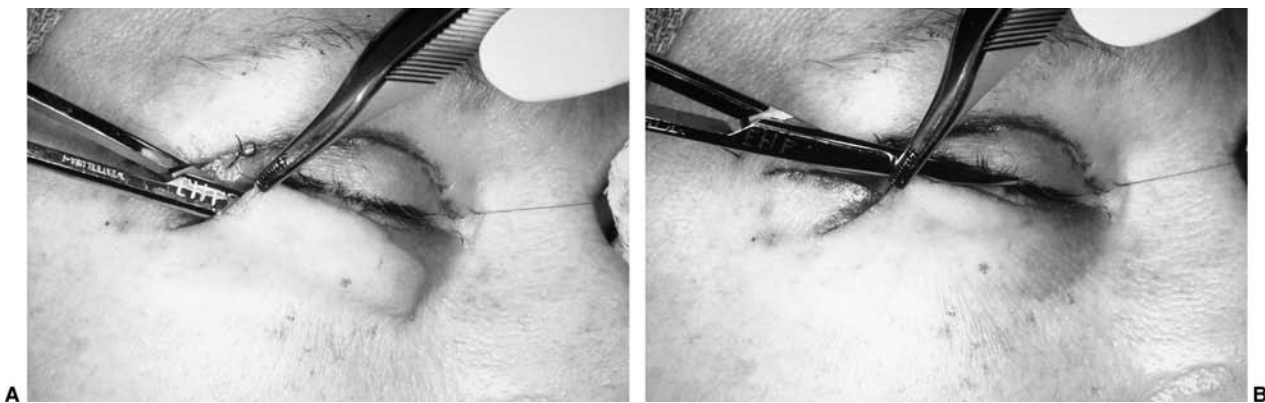


FIGURE 6-20 (A) Blunt dissection after subciliary incision in a submuscular plan. (B) Completion of the subciliary incision with angling of the tenotomy scissors to preserve the pretarsal orbicularis oculi muscle.

described with a transconjunctival blepharoplasty. The skin muscle flap is then redraped. If the patient is awake, the mouth is opened. The skin is marked and excess skin excised using the tenotomy scissors. At the time of skin excision, the blade of the scissor beneath the orbicularis oculi muscle is turned inferiorly to resect some orbicularis oculi muscle from beneath the skin of the lower eyelid so that there is no overlap of preseptal orbicularis oculi muscle causing duplication of the muscle.

After excessive skin is resected, hemostasis is again obtained. A small suborbicularis oculi muscle tunnel is developed superior to the incision over the lateral orbital rim extending to a point above the lateral canthal tendon.

At this point a 4-0 Maxon suture is used and the periosteum of the medial surface of the lateral orbital rim above the lateral canthal tendon is grasped and sutured to the cut edge of the orbicularis oculi muscle on the skin muscle flap, trying to prevent dimpling of the skin while suspending the skin muscle flap to the periorbital. After this skin muscle flap is redraped, an individual suture is placed at the level of the lateral canthus; then the remaining incision is closed with a running subcuticular nylon suture and some double throw knots in the skin lateral to the lateral canthus of the eye.

The pinch technique for lower lid blepharoplasty with transconjunctival fat excision is extremely popular. This

was originally described by Parkes et al.⁷ After transconjunctival fat excision, the subciliary skin is pinched with a forceps and compressed with a hemostat following the ridge of skin, which develops beneath the subciliary margin. The skin is then resected, maintaining the preseptal orbicularis muscle, and the wound is closed. The advantage of this technique is that it prevents the disruption of tissue from the ciliary margin down to the inferior orbital rim. The perception is that the disruption of tissue from the subciliary skin to the orbital rim may lead to a cicatrix, which could create ectropion.

As with all surgical procedures, the more thought that goes into the techniques for addressing deformities, the more likely new techniques will develop. This has been the case over the past 10 years with the development of techniques to preserve and reposition rather than to excise tissue of the lower eyelid in efforts to create a more youthful appearance. The repositioning of orbital fat into soft tissue defects centrally beneath the orbital rim and the elevation of the suborbicularis oculi fat (SOOF) correct the extended soft tissue paucity over the orbital rim (Fig. 6-17D). These two procedures are important to integrate into the management of the lower eyelid, re-creating the youthful complex of a single mildly convex profile line as described by Hamra.⁸ The tear trough or nasojugal groove has always presented a challenge in eyelid rejuvenation, and when excess fat is

eliminated in efforts to correct this shallow appearance, overexcision may occur, leading to a more wasted appearance.

Fat mobilization can be performed in conjunction with SOOF elevation or as an isolated procedure. After skin muscle flap is elevated, this is extended beneath the SOOF over the orbital rim and face of the maxilla. It can be extended using blunt or sharp dissection. Once soft tissue is elevated off the maxillary periosteum nasally for ~1 cm and laterally for ~2 cm, the SOOF is easy to identify superficial to the soft tissue dissection. The orbital septum is divided just above the orbital rim and herniating fat is transposed and sutured inferiorly to the periosteum over the face of the maxilla (Fig. 6-21A,B). This technique is described in some detail by Baker.⁹

If fat mobilization is all that is necessary to address the problem, then the skin flap is redraped, redundant skin is resected at this point, and the wound is closed. The shallow appearance over the orbital rim laterally is sometimes hard to correct with orbital fat mobilization and it is frequently helpful to combine SOOF elevation (Fig. 6-21C). Laterally the SOOF is grasped and suspended to the periosteum of the lateral orbital rim and orbital floor immediately inside the inferior orbital rim using a clear nylon or long-acting absorbable suture. This provides some elevation of the midface but adds

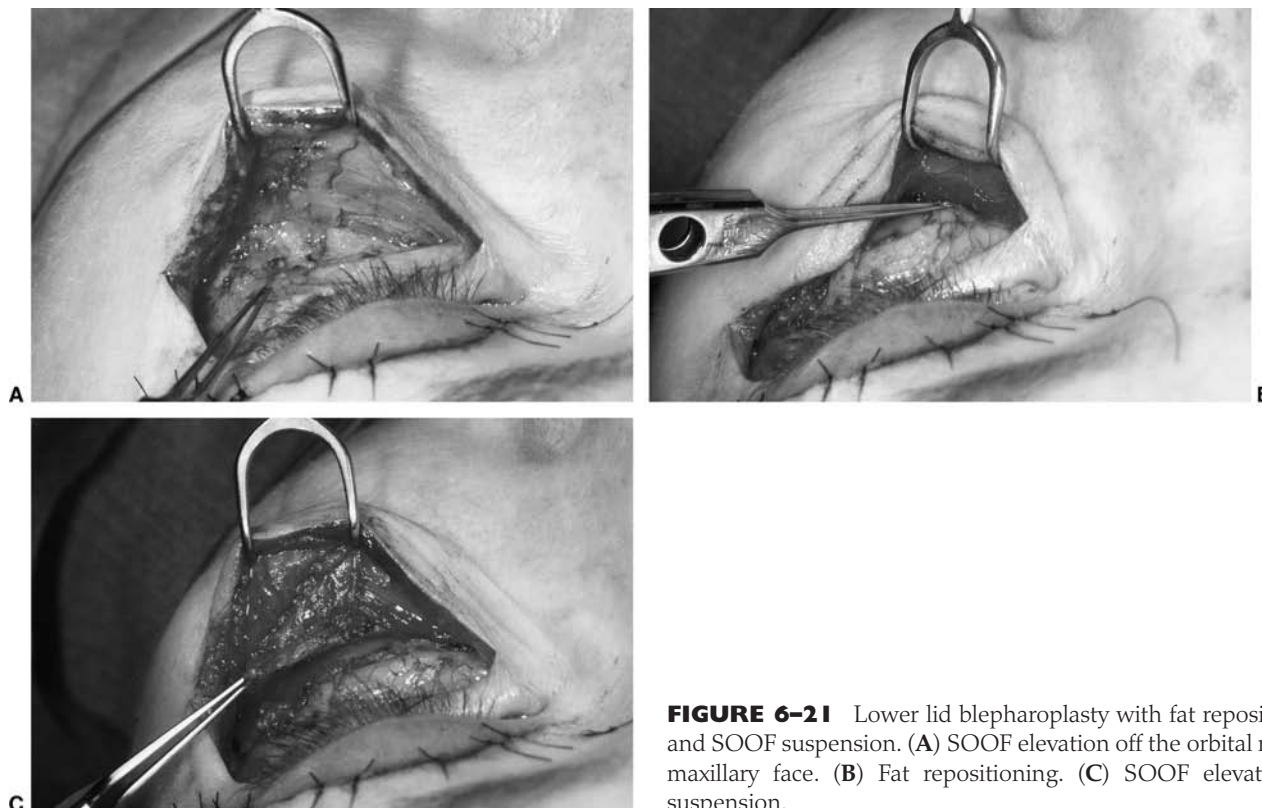


FIGURE 6-21 Lower lid blepharoplasty with fat repositioning and SOOF suspension. (A) SOOF elevation off the orbital rim and maxillary face. (B) Fat repositioning. (C) SOOF elevation for suspension.

additional soft tissue to correct the shallow appearance at the orbital rim. The skin muscle flap is then redraped and marked, and redundant skin excised prior to the SOOF elevation and suspension (Fig. 6–22).

Postoperative Care

Cool, moist compresses are placed on the eyes immediately following the completion of the surgery and are maintained as constantly as possible for the next 72 hours. It is important to avoid direct contact of noninsulated ice with the eyelid skin. All patients are given a prescription for an ophthalmic antibiotic ointment to apply to the incisions. The tarsorrhaphy suture is removed immediately upon the completion of the surgical procedure so visual acuity can be addressed and to avoid any claustrophobic anxieties that may develop immediately postoperatively.

All patients are given prescriptions for antibiotics and pain medication. It is seldom necessary for the pain medication to be taken beyond the first 24 hours postoperatively. The patients are instructed to return in 2 to 3 days after their surgery, at which time the surgical twists are removed from the lateral portions of the incision. The running subcuticular suture remains in place for 8 to 10 days. Eye makeup is not allowed for 3 weeks.

Complications

Complications from blepharoplasty are infrequent but may be catastrophic if they occur. Preoperative planning, sound surgical principles, and preventative measures are the most prudent approach. In the acute postoperative period, swelling and bruising with occasional bleeding from the incisions can occur, and usually respond to cold compresses. If there is any complaint of severe pain within the eye or changes in visual acuity, consideration must be given to the possible development

of a retrobulbar hemorrhage causing pressure on the globe and traction on the optic nerve.

As with all surgical procedures, bleeding, infection, and hematoma may form. Postoperative complications occurring specifically after blepharoplasty include lagophthalmos, corneal abrasion, ectropion, diplopia, and blindness. Meticulous surgical technique helps to reduce the likelihood of all these complications. A tarsorrhaphy suture placed between the upper and lower eyelid before the initiation of surgery or after the completion of the transconjunctival portion helps to prevent overzealous excision of lower eyelid skin while protecting the globe during the surgical procedure. All skin muscle flaps are suspended to the periosteum of the lateral orbital rim above the lateral canthal tendon to maintain support and help minimize the risk of ectropion. When fat excision is performed, the vessels within the orbital fat need to be respected. Cross-clamping of the base of the fat, excision of excessive fat, and the bipolar cautery of the stump both while it is held in the hemostat and once released should assure hemostasis.

Retrobulbar hemorrhage is a presumed source of most cases of blindness after blepharoplasty, and the risk of this can be decreased by control of the fat stump during cauterization but more importantly by informing patients of this rare risk so they are alerted and do not ignore any early symptoms.

FACELIFT

The last quarter of the 20th century was noted for numerous advances in facial plastic reconstructive surgery including the more structurally sound rhinoplasty, the extended lower lid blepharoplasty, advances in skin resurfacing, and the modification of facelift techniques in efforts to address the complete lower two thirds of the face. From the subcutaneous

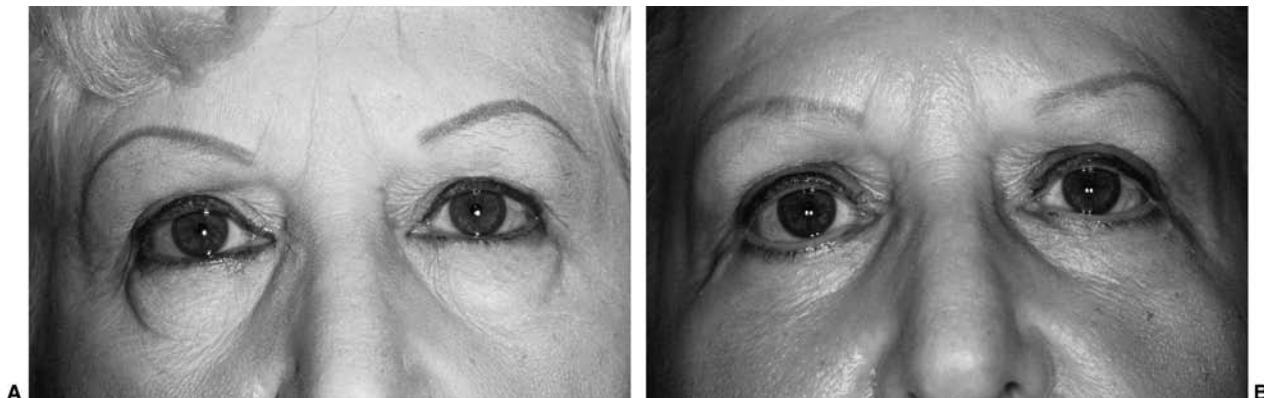


FIGURE 6–22 Preoperative (A) and 1-year postoperative (B) photographs following lower lid blepharoplasty with fat repositioning, SOOF suspension, and orbicularis oculi suspension at the lateral canthus.

musculoaponeurotic system (SMAS) to the sub-SMAS, composite, triplane facelift, and endoscopic facelift, extensive efforts have been made to improve results and extend the longevity of rhytidectomy.^{10–15} With these efforts have come an improved understanding of the anatomy of the midface and the anatomic changes that lead to the aging face.

Initially, facelifting was a skin-tightening procedure that did not pay attention to the other anatomic changes that occur or the support mechanisms of facial skin. Most of the abnormalities addressed with the skin flap facelift were those that involved loss of structure within the skin or intrinsic changes; less attention was paid to the changes caused by gravity, the descent of malar fat, the atrophy of subcutaneous and buccal fat, and the resorption of bone. As facelifting evolved, so did efforts to better address these contributions.

With time, it became evident that skin flap facelift was ineffective at long-term correction of undulation of the jaw, platysmal banding, and the melolabial fold. More extensive skin flap elevation and platysmal suspension then became popular in efforts to have a greater and longer lasting impact. These procedures progressed to SMAS elevation and imbrications, mid-line platysmal imbrication, platysmal division, and eventually the deep plane, composite, and triplane facelift. With each more aggressive technique, there were small but incremental improvements in the results, accompanied by comparable increases in the swelling, edema, ecchymosis, and recovery time from surgery. All of these techniques have their risks and should be approached in a graduated fashion when beginning a practice. Subperiosteal or deep plane facelifting should not be performed without first acquiring sufficient experience with cadaveric dissections to obtain a better understanding of the anatomy.

With skin flap elevation, the surgical procedure is done in a subcutaneous plane, and if meticulous hemostasis is performed, there is very little risk of damage to the facial nerve, hematoma, or infection. Once the skin flap elevation is extended more anteriorly, the blood supply to the flap becomes more compromised and can lead to epidermolysis and even full-thickness loss of the skin flap. As deeper planes of elevation became popular, the amount of skin flap elevation has shortened, decreasing the risk of skin loss.

Anatomically, the SMAS is thought to be a continuation of the fascial planes enveloping the platysmal muscle extending into the midface up to the zygomatic arch and inferior border of the orbicularis oculi muscle. There are conflicting anatomic reports as to whether or not this is consistent with the superficial layer of the parotid fascia.¹⁶ It is thought to be analogous to the aponeurotic system enveloping the frontalis and occipitalis muscles, although there is a discontinuity at the zygomatic arch.

Injury to the facial nerve is certainly the most catastrophic consequence. Understanding of its anatomic position in the midface is important. After exiting the stylomastoid foramen and coursing through the parotid gland, the facial nerve divisions exit the anterior border of the parotid gland and arborize beneath the SMAS. The frontal branch of the facial nerve exits superiorly and crosses the zygomatic arch at a position halfway between the sideburn and lateral orbital rim ~1.5 cm posterior to the lateral canthus entering the temporoparietal fascia at this level. The nerve is at greatest risk as it crosses the zygoma entering the forehead. With elevation of the superior portion of a facelift being done in a subcuticular plane, the nerve is deep immediately adjacent to the zygomatic arch. With elevation of the periosteum off the zygomatic arch, when elevating in a deep plane, care must be taken to avoid injury to the nerve. The danger zone in surgical elevation in the region of the zygomatic arch extends from an area 1.8 cm anterior to the helical root and 2 cm posterior to the junction of the zygomatic arch and lateral orbital rim.

The zygomatic division of the facial nerve that innervates the orbicularis oculi muscle exits the anterior border of the parotid gland adjacent to the inferior border of the zygomatic arch at its junction with the malar eminence on the masseter muscle deep to the parotidomasseteric fascia and superficial to the masseter. This nerve crosses deep to the zygomaticus major and minor muscle, innervating these muscles from their deep surface (Fig. 6–20). The zygomatic branch of the facial nerve exits the parotid gland posterior to the fascial incision in a deep plane facelift. If dissection is maintained superficial to the zygomaticus major muscle, then risk to this branch of the facial nerve is controlled.

The buccal branch of the facial nerve also exits the anterior border of the parotid gland adjacent to and just below Stensen's duct running anteriorly on the masseter muscle deep to the parotidomasseteric fascia and superficial to the buccal fat pad. This branch of the facial nerve is at the greatest risk when dividing the fascia for a deep plane facelift.

The marginal mandibular branch of the facial nerve, which is a common branch to be injured, exits the anterior/inferior border of the parotid gland just anterior to the angle of the mandible and drops beneath the margin of the mandible running on the deep surface of the platysma muscle about 1 to 2 cm below the margin of the mandible. It courses over the submandibular gland where it will again cross the margin of the mandible anterior to the facial vessels to innervate the perioral muscle about 2 cm lateral to the oral commissure. With platysmal elevation and suspension during facelifting, care should be taken in elevating the platysma at any level anterior to the angle of the mandible, and if the platysma should be divided, it should be divided more than two fingerbreaths inferior to the margin of the mandible.

While performing the fascial incision for a deep plane facelift, this portion of the incision is over the parotid gland where the facial nerve should be protected within the gland, but it is at greatest risk when the platysma muscle is dissected or divided. The most common nerve injured with a facelift is the greater auricular nerve, which provides sensation to the inferior half of the ear. This nerve exits the cervical plexus running in a subcutaneous plane superficially over the sternocleidomastoid muscle. In this area, the adherence between the sternocleidomastoid muscle and subcutaneous tissue is evident in neck dissection, and care must be taken to stay in a relatively shallow subcuticular plane.

Preoperative Preparation

The preoperative preparation of the facelift patient begins at the initial consultation with an honest discussion of the patient's goals, motivations, and expectations for this surgery. Limitations of the operation and the trade-off of facial rejuvenation for a well-camouflaged scar should be discussed. Asymmetries and other anatomic inadequacies that are not addressed by the facelift procedure should be pointed out to the patient so that the limitations of the result can be understood and adjunctive procedures considered.

Preoperative skin hygiene, including glycolic acid peels and microdermabrasion, helps to cleanse and refresh the skin and may enhance the result from a facelift. Patients who can expect the best overall result have excellent skeletal support, some remaining elasticity in the skin, and minimal solar elastosis and deep rhytids.

After patients have been scheduled for surgery, they are prescribed 1000 mg of vitamin C three times a day for 2 weeks prior to undergoing surgery as an antioxidant to expedite healing. They are also told to discontinue any nonsteroidal antiinflammatory agents as well as over-the-counter nutritional supplements whose impact on surgical result and hemostasis may not be appreciated. Patients are also instructed to stop any hair care products several days prior to surgery including sprays and gels. The hair is washed the night prior to surgery and the morning of surgery. When patients arrive at the surgical facility, they are marked in the upright position. Facial adiposity, rhytids, platysmal banding, and any specific abnormalities that may need to be addressed are marked. The incisions are also marked with the patient in the upright position to assure symmetry.

Surgical Execution

The patient is taken to the operating suite where the induction of anesthesia takes place. With the more extensive nature of a deep plane facelift, most rhytidesctomies are now performed under general anesthesia supplemented by infiltration with 0.5% lidocaine and

1:200,000 epinephrine. Some surgeons prefer the supplementation of local anesthesia with a longer-acting agent to decrease the degree of postoperative pain and, it is hoped, expedite the discharge if narcotics are not needed postoperatively.

After the patient is intubated and positioned, the first side of the facelift to be performed is infiltrated. If the direct approach to the submental area is necessary, the area is infiltrated and approached first. Hair at the margin of the incisions is trimmed with scissors but is not shaved. Most of the areas where the hair is trimmed are excised at the time of redraping. The bed is positioned with the anesthesia provider's machine at the patient's feet. A regular endotracheal tube is used and is stabilized to the upper lip with a Tegaderm (3M Healthcare Ltd., St. Paul, MN) dressing. This is easy to prep and sterilize, interfering least with the flap elevation and surgical execution and allowing access to the submental area. Patients receive a broad-spectrum intravenous antibiotic prior to the initiation of surgery.

Incisions

There is no prescribed incision for facelifting. The incision must be designed to take into account optimal camouflage and the vectors necessary to obtain the best facelift result with the least noticeable scar. These decisions are affected by hairline, male beard, the vectors needed to obtain the best facelift result, previous surgery, prominence of the tragus, degree of platysmal banding, skin laxity, pretragal rhytids, and the lobular position.

In the optimal patient where there is an adequate tuft of sideburn hair, a strong but not overly prominent tragus, a detached lobule, and minimal banding and redundancy of neck skin, the most camouflaged incision can be made (Fig. 6–11). In these patients the incision is made in a curvilinear fashion within the temporal hair proceeding in a retrotragal preauricular fashion circling beneath the lobule maintaining approximately a 2-mm margin between the incision and the lobular attachment, then proceeding onto the posterior surface of the ear approximately 0.5 cm lateral to the postauricular sulcus, crossing to the postauricular hair at a level even with the junction of the superior and inferior crus of the antihelix, which corresponds to the area where the postauricular hairline meets the posterior border of the helical rim (Fig. 6–23). The incision then extends posteriorly into the hair. This incision creates elevation and posterior displacement of the sideburn hairline postsurgically as well as the possibility of notching at the postauricular hairline if the vector on the postauricular skin is not more superior than posterior. The patient as described here provides the ideal candidate for camouflage.

The facelift incision is then customized depending on specific concerns that need to be addressed. In the female



FIGURE 6-23 (A) Preoperative postauricular markings of the facelift incision on the posterior surface of the conchal bowl and crossing the postauricular sulcus at the level of the junction of the superior and inferior crus of the antihelix. (B) Postoperative photograph of the postauricular incisions.

with a naturally occurring minimum sideburn tuft of hair or in the patient who has undergone previous rhytidectomy with elevation and posterior displacement of the sideburn hair, a trichophytic incision is made trying to bevel inferiorly to transect some of the hair follicles at the margin. This incision follows the hairline and extends temporally at the margin of the hair (Figs. 6-11 and 6-24).

In patients with an overly prominent tragus, raising concerns that this might flatten with a retrotragal incision, or in patients with deep preauricular rhytids, or in male patients, a pretragal incision is made. In the male patient this incision is made halfway between the tragus

and the posterior border of the sideburn to preserve the preauricular non-hair-bearing skin and avoid the placement of beard onto the tragus. In addition, in the male patient, the incision is made 3 to 4 mm beneath the margin of the attachment of the lobule, and the postlobular crease remains on the non-hair-bearing skin of the mastoid rather than proceeding on the posterior surface of the auricle. This prevents the placement of hair-bearing skin immediately adjacent to the lobule or within the postlobular crease.

With extensive redundancy of skin in the neck and severe platysmal banding, the vector of the postauricular



FIGURE 6-24 (A) Preauricular trichophytic incision in a retrotragal fashion. (B) One-year postoperative.

pull needs to be in a more posterior direction. For this reason, the postauricular incision is made following the margin of the hair again, making an effort to amputate some hair follicles so that these will regrow through the incision. The sideburn and temporal portion of the incision in the male can be modified according to preference, hair type, and beard (Fig. 6–11). The incision has a dart within the temporal hair just above the superior auricular attachment, which then proceeds inferiorly across, going beneath the sideburn and following the temporal hairline. This preserves the most natural sideburn and frequently is completely camouflaged when the beard regrows.

Flap Elevation

Postauricular flap elevation is initiated after the incision is made, prior to making the preauricular portion of the incision. For postauricular flap elevation the lobule is grasped and transposed anteriorly. A skin hook is placed at the apex of the incision in the postauricular sulcus and an additional hook is placed further inferiorly along the hairline. A No. 15 blade is used to elevate a subcuticular flap. Over the head of the sternocleidomastoid muscle, this flap must be elevated in a shallow subcuticular plane to avoid transecting the great auricular nerve in the region where the fascia of the sternocleidomastoid muscle interdigitates with the subcuticular tissue. In the immediate postlobular area, the skin flap is quite thin because of the paucity of fat at this level. It is easy to either penetrate the flap in this area or dissect into the anterior border of the head of the sternocleidomastoid muscle. Subcuticular elevation is performed with a knife to a point extending from the infralobular portion of the incision posteriorly to just beneath the inferior extent of the incision. At this point, Metzenbaum scissors are used in a pinching fashion, advancing incrementally in multiple tunnels as far anterior as is possible. This frequently extends to a level consistent with the anterior border of the platysma muscle joining the submental elevation. This extended cervical subcuticular elevation does not extend more superiorly than one fingerbreath beneath the margin of the mandible (Fig. 6–23). After this flap is elevated, hemostasis is obtained with bipolar electrocautery and the pocket is packed.

The temporal and preauricular portion of the incision is made, and again skin hooks are used to stabilize the skin flap in a countertraction fashion without folding the flap anteriorly. The flap is displaced laterally. The No. 15 blade is used to elevate the flap beneath hair-bearing scalp in the temporal area and extending inferiorly where it is joined with the subcutaneous elevation in the cervical region beneath the lobule. Subcutaneous elevation extends anterior to the posterior border of the orbicularis oculi muscle in the temporal region ~1 cm anterior to the junction of the zygomatic arch and malar eminence and

1 cm anterior to the angle of the mandible. This provides adequate access for fascial incisions with a deep plane facelift while minimizing cutaneous elevation, creating a relatively short flap after redraping. The majority of this flap elevation is again performed using the facelift scissors (Fig. 6–25). The temporal portion of the incision can be performed superficial to the temporal fascia and deep to the temporoparietal fascia. If this dissection is performed in a deep plane rather than in a subcutaneous plane, an isthmus of fascia must be maintained at the zygomatic arch to prevent damage to the frontal branch of the facial nerve.

If flap elevation is maintained in a subcutaneous plane throughout the elevation, then there is minimal risk of damage to the facial nerve. The more extensive the flap elevation, the greater the risk of flap necrosis after surgery. Patients with a history of smoking and microvascular disease should have a shorter cervical flap elevation.

Subcutaneous Musculoaponeurotic System Elevation

After subcutaneous elevation is completed, first hemostasis is obtained with bipolar electrocautery. At this point, whether an SMAS facelift or deep plane facelift is to be performed, preauricular soft tissue, including the posterior border of the SMAS, is trimmed to prevent duplication of tissue and a possible ridge after imbrication (Fig. 6–26). This maneuver is performed grasping the preauricular areolar tissue 1½ to 2 cm anterior to the root of the helix at the level of the inferior border of the zygomatic arch. Facelift scissors are then used, and this fascia is resected extending in an inferior-posterior direction to a level just inferior to the angle of the mandible. This resection should occur superficial to the superficial parotid fascia. This soft tissue may be discarded or used as a filler graft for lip augmentation, melolabial augmentation, or buccal fat atrophy.

After the preauricular tissue is resected, the anterior margin of that resection can be grasped with a Cushing forceps and dissected to the anterior border of the parotid gland. It has been my experience that the ease of dissection within this plane is quite variable and, in many cases, extremely adherent to the parotid fascia, making this dissection difficult. Care should be taken not to enter the superficial lobe of the parotid gland. This posterior SMAS elevation can be extended inferiorly with subplatysmal elevation.¹⁰ The degree to which a platysmal muscle is elevated varies extensively. Owsley¹⁷ performs an extensive subplatysmal elevation and resuspension of the posterior border. At this point during my dissection with SMAS or deep plane facelift, extensive subplatysmal elevation is executed, remaining as far inferior as possible with visualization of the external jugular vein. Once the platysma is elevated to the extent of the Metzenbaum scissors, a blade of the scissors is



FIGURE 6-25 (A) Diagrammatic representation of the planes of elevation in the slipping deep plane facelift. (B) Pre-operative markings indicating subcutaneous, subplatysmal, and deep plane elevation.



FIGURE 6-26 (A) Forceps grasping the preauricular areolar tissue at the level of the zygomatic arch to initiate trimming. (B) Excision of a strip of preauricular areolar tissue to avoid soft tissue redundancy in the preauricular area after subcutaneous musculoaponeurotic system (SMAS) or deep plane elevation and suspension.

placed superficial and deep to the platysmal flap. The scissors is displaced inferiorly to maintain an adequate margin away from the marginal mandibular nerve, and the platysma muscle is divided. If the deep plane of

elevation is immediately beneath the platysma muscle, there should be minimal bleeding. Hemostasis is obtained at this point, and the neck is packed if one is proceeding with a deep plane facelift. If not, the posterior

border of the SMAS is grasped and imbricated to the zygomatic arch, preauricular soft tissue, and mastoid cortex with a more superior vector on the face and preauricular area and a more posterior superior vector toward the mastoid cortex. The skin is then redraped, marked, excised, and closed.

Deep Plane Facelift

With a deep plane facelift as described by Hamra,¹¹ the subcutaneous elevation is the same as what has been described to this point. The preauricular fat and fascia are trimmed but no elevation is executed over the parotid gland. The subplatysmal flap is elevated and the platysma divided as described. The malar eminence is then palpated with the index finger and the angle of the mandible is palpated with the thumb, and a No. 15 blade is used to score the soft tissue in a line from the index finger to the thumb (Fig. 6-25). After the areolar tissue is scored, blunt and sharp dissection is used to enter the level of the deep plane. Spreading in the direction of the facial nerve is performed to avoid undue trauma.

The plane of dissection extends anteriorly over the masseteric fascia where the buccal division of the facial nerve is visualized accompanying Stensen's duct. This dissection extends anteriorly over the buccal space in the cheek and to the level of the mental foramen over the mandibular body. Elevation does not include the separation of fascia at the margin of the mandible anterior to the posterior edge of the mandibular notch.

The most difficult and tedious portions of this dissection are in the vicinity of the zygomatic branch of the facial nerve immediately adjacent to the malar eminence (Fig. 6-27). This portion of the dissection is initiated superiorly and performed in a suborbicularis plane extending anteriorly over the face of the maxilla just inferior to the orbital rim to the level of the infraorbital nerve. This is done with blunt dissection and extends inferiorly with identification of the zygomaticus major and minor muscles. Cephalic to the zygomaticus major, the dissection is performed superficial to the zygomaticus major in a deep subcuticular plane, which protects the branches of the facial nerve. Immediately

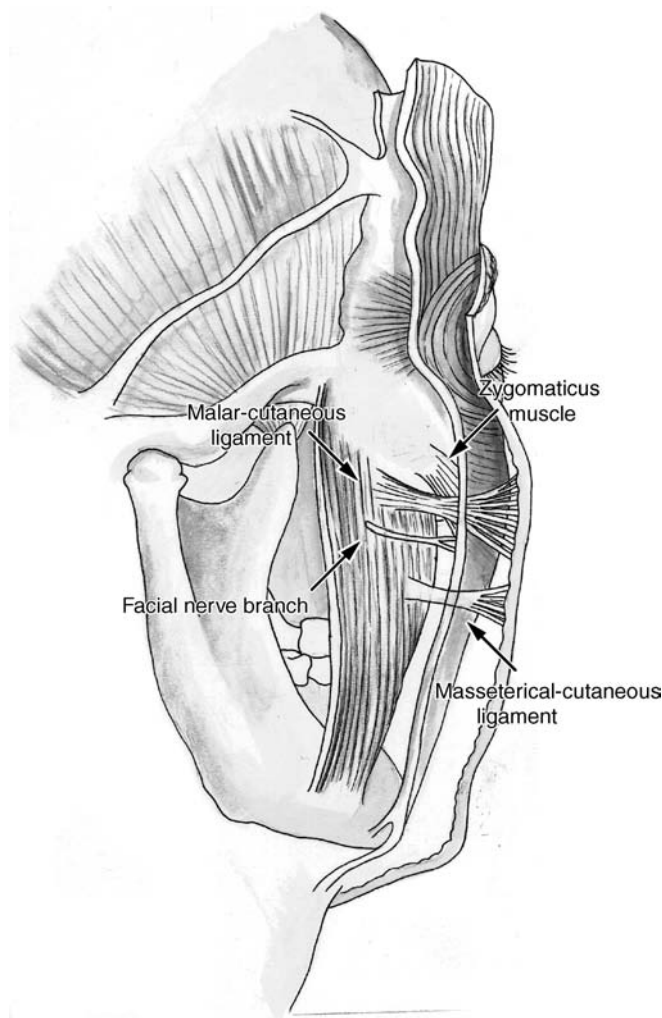


FIGURE 6-27 Diaphragmatic representation of the ligamentous and fascial attachments of the facial musculature and soft tissue.

deep to the zygomaticus muscles, one encounters the zygomatico-cutaneous ligament, which is a dense accumulation of connective tissue. This is usually superior to the zygomatic branch of the facial nerve. While grasping the flap, blunt dissection is used to separate this connective tissue. The release of this ligament is obvious with the impact on the melolabial fold and the mobility of the upper portion of the facelift including the cheek and melolabial area (Fig. 6–28). A bridge of areolar tissue is left intact at the margin of the mandible to protect the marginal mandibular branch of the facial nerve (Fig. 6–29).

Once elevation is completed, the flap is then resuspended to the fascia of the temporalis muscle, the malar eminence, and the zygomatic arch. The areolar tissue adjacent to the zygomaticus muscle is sutured superiorly with a 3-0 Maxon suture in a horizontal mattress fashion. All sutures resuspending a SMAS or deep plane lift are

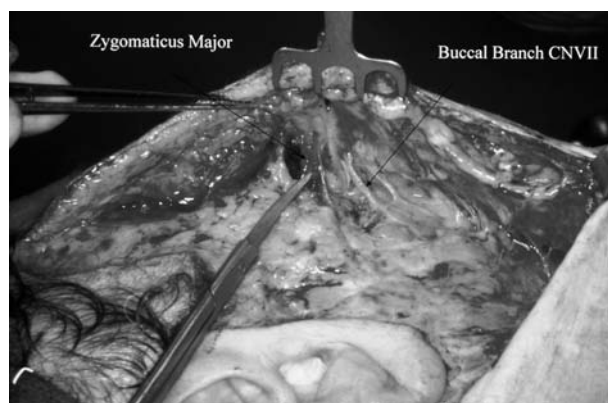


FIGURE 6-28 Dissection in the vicinity of the zygomaticus muscle, buccal division of the facial nerve, and zygomatico-cutaneous ligaments can be particularly tedious and should be done with great caution.

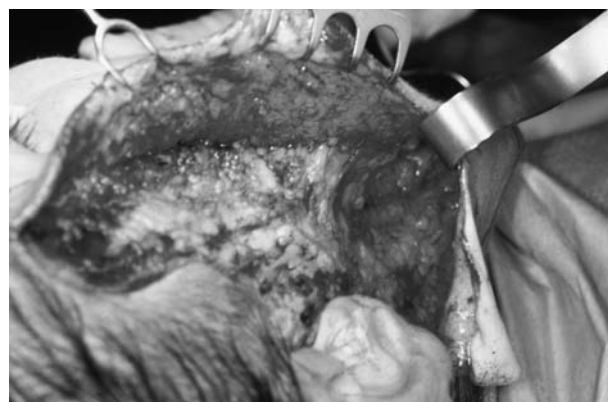


FIGURE 6-29 Deep plane and subplatysmal elevation maintaining an isthmus of soft tissue at the margin of the mandible to protect the marginal mandibular branch of the facial nerve.

placed in this fashion. Subsequent sutures extend from the border of the flap to the zygomatic arch and preauricular soft tissue. The posterior border of the platysma muscle inferiorly is suspended to the mastoid cortex and dense fascia of the superior portion of the sternocleidomastoid muscle. Once suspension is completed, additional simple interrupted sutures may be placed to further secure the deep plane flap. Occasionally, the deep plane flap must be divided at the level of the lobule to split around the lobule and prevent the bunching of the lobule and flap.

If extensive submental platysmal banding exists, the platysmal imbrication is initiated and completed prior to deep plane elevation and suspension. Through a submental incision, subcutaneous flaps are elevated either after or before the completion of closed or open lipocontouring. After the subcutaneous flap is elevated, the anterior border of the platysma muscle in the submental area is identified. Elevation extends deep to the platysma muscle inferiorly for ~3 cm, and the anterior border of the platysma muscle is trimmed and is divided for 3 cm posteriorly at the level of the hyoid bone. The anterior border of the platysma muscle is then imbricated using a 4-0 Maxon suture. Hemostasis is obtained and the submental incision is closed.

With the deep plane and composite rhytidectomy there has been disappointment with the impact on the melolabial fold. In efforts to address these concerns, Baker¹³ has advanced the triplane rhytidectomy, which is a combination of a sub-SMAS rhytidectomy and a subperiosteal midface release. After subcutaneous and deep plane elevation is performed, a small incision is made immediately over the junction of the zygomatic arch and malar eminence, and the periosteum is elevated and released from this point forward. An additional gingival buccal sulcus incision is made, and the periosteum over the face of the maxilla is also released from the piriform aperture and maxillary buttress. After the periosteum is elevated and released, sutures are used to suspend the flap posteriorly and superiorly. The skin is again redraped, marked, and excised.

Redraping and Trimming

After the fascia is resuspended and stabilized, the skin flap is redraped. In the temporal area the vector is superior; in the preauricular area the vector is perpendicular to the melolabial fold, and this same vector of traction is maintained in the postauricular portion of the flap. Even traction is placed on the flap by the placement of Allis clamps at the level of transition of the incision between the temporal and preauricular incision, the tragus, and the point where the incision crosses the postauricular sulcus from the ear to the hairline (Fig. 6–30). After redraping is performed the flap is stabilized with towel clips placed at the root of the helix and the superior portion of the incision in the postauricular sulcus. Even traction is maintained on



FIGURE 6-30 (A,B) Redraping of the cutaneous flap after deep plane suspension and stabilization with marking.

the existing Allis clamps, and the flap is marked under direct visualization.

With the SMAS elevation and deep plane elevation, minimal to no tension is placed on the wound besides efforts to smooth and evenly distribute the excess skin. Occasionally, dimpling occurs at the sites of deep plane suspension, and it is better to elevate subcutaneously over this dimpling than to try and pull the skin flap excessively to eliminate it.

The skin is resected with attention to beveling the incision in the direction of the hair follicles in hair-bearing areas and beveling away from the incision in non-hair-bearing areas to provide the best scar possible. The incision is then closed with interrupted subcuticular Maxon sutures; 4-0 Maxon is used at points of transition from each area in the flap from the temporal incision to the preauricular incision, from the preauricular to the postauricular incision, and from the postauricular

incision to the posterior hairline incision. After 4-0 Maxon sutures are secured, the towel clips are removed and multiple evenly spaced 5-0 Maxon sutures are used to further approximate the wound margins. After subcuticular closure is completed, a staple skin approximator is used in hair-bearing areas. The preauricular incision is closed with a running subcuticular 5-0 nylon suture and the postauricular incision is closed with a running locked nylon suture. Efforts are made to secure pressure on the completed side of the facelift while the second side is addressed; closed wound suction may be applied. Prior to closure of the wound, a Hemovac drain is placed into the wound, which extends deep into the cervical portion of the flap and up over the face to the level of the zygomatic arch. This drain is removed prior to discharge of the patient from the surgical facility.

Platelet gel¹⁸ and other forms of tissue adhesive have been presented as options to assist in healing (Fig. 6-31).



FIGURE 6-31 A patient 24 hours after blepharoplasty deep plane facelift. (A) Without the application of platelet gel. (B) With the application of platelet gel.

Postoperative Care

After the dressing is secured using fluff, Kerlix roll, and Kling and Coban dressing, the patient is taken to the recovery area where the head remains elevated at 30 to 45 degrees. Closed wound suction can be continued, and cold compresses are placed over the exposed portions of the face. The dressing remains in place for 48 hours after the surgery. If the patient complains of increasing pain, discomfort, tightness, or respiratory distress, the dressing is removed to evaluate for possible hematoma and then replaced. Most patients and their families prefer having the wounds covered in the first several days after surgery to avoid the otherwise necessary wound care.

After the dressing is removed, patients are instructed to clean the incisions with peroxide and applying antibiotic ointment twice a day. They are also encouraged to continue to sleep with their head elevated for 3 weeks after the surgery. They are allowed to shampoo their hair 72 hours after the surgery, taking care in the vicinity of the incisions. Half the staples are removed at 5 days, with the remainder being removed at 10 days. All sutures are out by 10 days after the surgical procedure. After 72 hours, patients are instructed to alternate cold and warm compresses for 30 to 60 minutes three to four times a day. They are also told to continue taking vitamin C 2000 to 3000 mg a day. They are instructed to avoid sun exposure as completely as possible for 6 months.

As an adjunct to the postoperative management of patients undergoing elective cosmetic surgery, platelet gel has been used to reduce the need for closed wound suction and postoperative dressings. The clinical reports are mostly anecdotal to this point but do indicate a marked improvement in postoperative ecchymosis and swelling, and a decrease in the need for closed wound suction and drainage.¹⁸ Growth factor and other platelet-derived factors are indicated in improved wound healing. By applying platelet gel, these factors can be increased manyfold. This is a relatively simple technique whereby, after the patient is under anesthesia, a unit of blood is withdrawn. Usually this is performed during the infiltration and preparation time, not to delay the surgery. The blood is separated with extraction of platelets. This solution can then be refrigerated or maintained at room temperature until application is desired. After the SMAS or deep plane suspension has been performed, the platelet solution is combined with thrombin and calcium to create a gel. The combination can either occur during an atomized phase simultaneous with the application of the solution to the wound, or the thrombin and platelets can be mixed in a syringe and applied through a large-bore angiocatheter to the wound. The skin is then redraped and closed.

Complications

One would anticipate that with the increased complexity of the deep plane and triplane rhytidectomy there

would be an increase in the complication rate. This has not been evident. There is certainly an increase in the acute postoperative sequelae, which, it is hoped, might be alleviated with the application of platelet gel and platelet-derived growth factor. With the more extensive surgery, the sequelae are expected to be more pronounced and may persist for a longer period of time.

True complications from facelift surgery include numbness, facial paralysis, hematoma, skin necrosis, scarring, and distortion of the ear. These complications must be minimized, if not eliminated, to make elective cosmetic surgery justifiable. Complications must be discussed with patients preoperatively and distinguished from sequelae of the surgery, either temporary or permanent. The sequelae of the surgery include a well-camouflaged scar, a change in the position of the hairline, numbness of the skin immediately over the cutaneous elevation, which may persist for 6 to 12 months after the surgery, and an overly tight sensation of the face, or neck, which usually resolves at 6 to 8 weeks postoperatively.

Benign hematomas are the most common complication of facelift surgery and may become noticeable from the time the dressing is removed to 10 days after the surgery. These usually measure about 2 to 3 cm in diameter and may cause increased discoloration of the skin flap, but do not pose a threat to the viability of the skin flap. Benign hematomas can be allowed to liquefy prior to evacuation but should be evacuated to expedite the resolution of bruising and healing. Evacuation can be performed with an 18-gauge needle and a 10-cc syringe after liquefaction has occurred.

Expanding or malignant hematomas usually occur within the first 12 hours after surgery but can occur up to 36 or 48 hours postoperatively. Expanding hematomas can compromise the viability of the skin flap and must be evacuated as soon as recognized. Seldom can they be evacuated and controlled with a dressing. Returning the patient to the operating room, opening the wound, and localizing the bleeding is usually necessary. Expanding hematomas are most frequently accompanied by discomfort, increasing agitation, and swelling. They usually necessitate maintaining a dressing in place for 2 to 3 extra days after the evacuation and control of the bleeding.

Nerve injuries can occur with a rhytidectomy. The most common nerve injured is the great auricular nerve because of its superficial course over the sternocleidomastoid muscle and the adherence of the skin at this point. Great auricular nerve injuries, if recognized, should be repaired, but the return of function of sensory nerves is inconsistent. Occasionally the nerve may be adjacent to cauterization or the placement of suspension sutures. These injuries should resolve with time but may take 12 to 18 months after the surgery.

Injuries to the facial nerve are most common in the frontal and mandibular branch. With deep plane facelift-ing, the buccal and zygomatic division is placed at

increased risk with the rate of partial or temporary paresis being reported as high as 3%. This usually represents a weakness in the function of the nerve but not a complete paralysis and generally resolves in 3 to 6 weeks after the surgery.

Skin flap necrosis can also occur when the skin flap is elevated too superficially, when the skin flap is too long, when hematomas occur, when the dressing is too tight, and in smokers. Necrosis of the skin flap should be managed conservatively with the application of antibiotic ointments. Debridement is discouraged because viable skin may be resected with the eschar, creating a full-thickness rather than partial-thickness injury.

A sequela that may become a complication is a poorly planned or executed scar. It is prudent not to resect skin beneath the lobule any lower than the level of the tragal notch. This prevents the overresection of the area and the distortion of the lobule postoperatively. Because of the extensive vascularity of the face, head, and neck, postoperative infection is extremely rare. Increasing pain, swelling, and erythema would manifest this. Occasionally, postoperative dermatitis will develop because of the application of antibiotic ointments, to which the patient may be sensitive. Any history of sensitivity should be elicited, ointment should be discontinued, and systemic and topical steroids initiated.

ADJUNCTIVE PROCEDURES TO RHYTIDECTOMY

Not all of the changes that occur as part of the aging process are simply a result of that process. Occasionally, preexisting underlying congenital variations exacerbate the normal aging process. These conditions include hypoplasia of the malar eminence, a congenitally deep melolabial fold, microgenia, and micrognathia. These abnormalities are frequently accentuated during the aging process with the natural descent of the hyoid-larynx complex, atrophy of subcutaneous and buccal fat, bone resorption, and loss of tone within the skin.

The evaluation and management of skeletal and soft tissue abnormalities of the midface are beautifully described by Binder¹⁹ and reflect six basic types. The recommendation for various implants is based on the abnormality present. The approach for placement of these implants may vary depending on the surgical procedures being performed concurrently. With the popularity of orbital fat repositioning to address a deep tear trough deformity, type 5 midface deformities may be more naturally addressed through fat repositioning. The remainder of the implants can be inserted with a gingival buccal sulcus incision or with transblepharoplasty. For the submalar implants, gingival buccal sulcus insertion is preferred.

The application of all midface implants is performed after positioning is assessed and marked with the patient in the upright position. Prior to marking the skin for implant location, the skin should be redraped to the

expected postsurgical position so that the orientation of the implant is not modified after facelift elevation. When blepharoplasty is being performed, it is my preference to insert malar and combined shell implants through the blepharoplasty incision, avoiding breaching the oral mucosa and reducing the risk of infection while also maintaining a stable pocket inferiorly. After the blepharoplasty flap is elevated, periosteum is incised and elevated over the desired pocket. When it is thought that an adequate pocket has been elevated, the implant is inserted. Frequently the pocket needs to be expanded posteriorly over the zygomatic arch and inferiorly over the masseter muscle. Once an adequate pocket is developed, the implant is inserted and stabilized to the periosteum with monocortical screws or sutures. The periosteum of the pocket is also closed to further stabilize the implant. The lid skin is then redraped and excised.

When implants are placed through a gingival buccal sulcus incision, the periosteum is elevated, and the implants are passed into the pocket using a draw suture passed percutaneously. Once the implant is in the pocket, it can be stabilized to the bone with rigid fixation or stabilized into the pocket through a percutaneous suture placed through a button. Rigid fixation is preferred in instances when simultaneous cervicofacial rhytidectomy is performed.

For the deep melolabial fold, which may not respond to the best of efforts with deep plane or triplane facelift, augmentation of the melolabial fold in a percutaneous or transnasal fashion can be executed. Implants may be placed through an intranasal incision at the piriform rim and a small puncture incision in the rhytid at the inferior extent of the rhytids (Fig. 6–32). Melolabial augmentation can be performed with one of several materials: acellular dermal matrix graft, expanded polytetrafluoroethylene (e-PTFE), preauricular fascia, or autogenous dermal fat fascial graft.²⁰ When a facelift is being performed, my preference is the autogenous dermal fat fascial graft or preauricular fascia.

A small incision is made in the piriform aperture and the tenotomy scissors are used to elevate a deep subcutaneous pocket. From a small puncture incision at the inferior extent of the rhytid, alligator forceps are passed in the deep subcutaneous pocket exiting at the piriform rim. The apex of whatever graft material is used is then grasped and drawn into the pocket and stabilized.

Each of these implants has advantages and disadvantages. With preauricular fat and fascia, it is an autogenous graft. It should be expected to survive, but if overaugmentation is performed, refinement is somewhat difficult. This would also be the case with the use of a de-epithelialized postauricular dermal fat fascial graft. The dermal fat fascial graft has a greater likelihood of survival and persistent augmentation of the melolabial fold, but may be more inclined to form epidermal cysts.

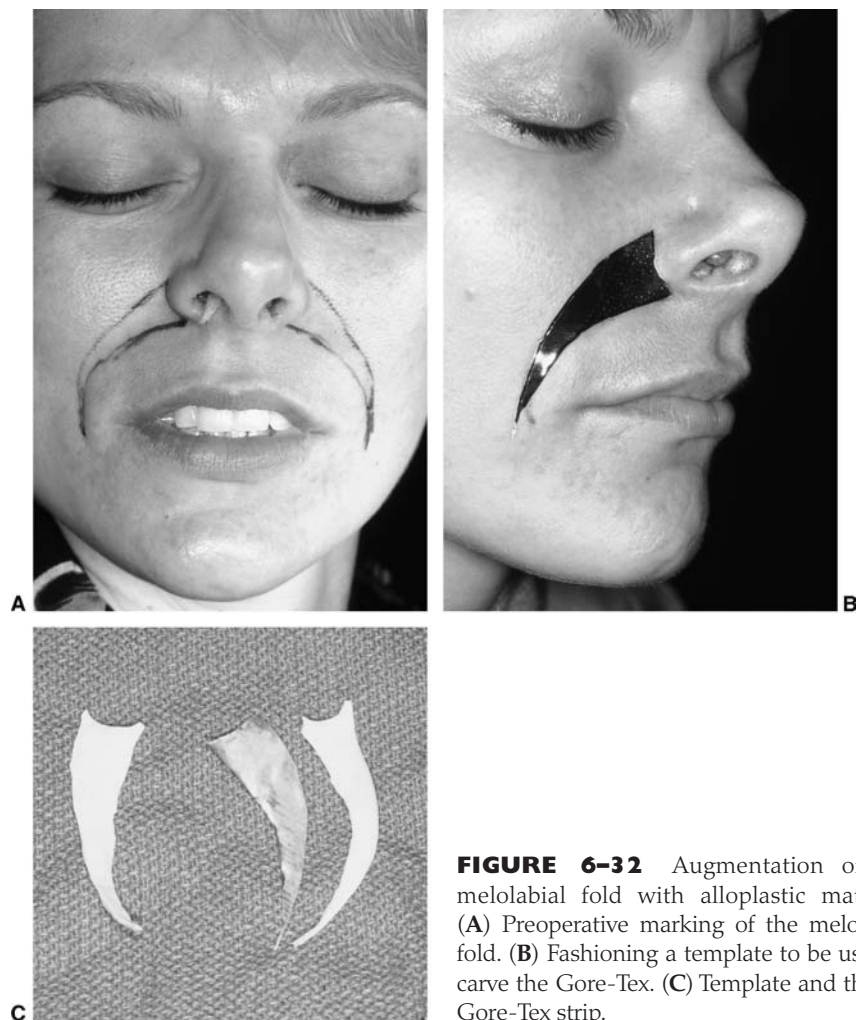


FIGURE 6-32 Augmentation of the melolabial fold with alloplastic material. (A) Preoperative marking of the melolabial fold. (B) Fashioning a template to be used to carve the Gore-Tex. (C) Template and the cut Gore-Tex strip.

Acellular dermal matrix grafts may be the easiest to apply but have not demonstrated persistence beyond 18 months. The use of e-PTFE (Fig. 6-33) is a good solution to the problem of permanency and ease of application or modification if desired; e-PTFE can be removed relatively easily, trimmed, and modified as necessary.

The problem with an alloplastic implant is that the risk of infection is greater and the implant will not assume the soft texture on palpation that Alloderm and autogenous grafts do. All these issues are discussed with patients preoperatively so that they can understand the advantages and disadvantages before making the decision.



FIGURE 6-33 (A,B) Preoperative and 1-year postoperative photographs after melolabial augmentation with Gore-Tex sheeting.

Enhancement to the chin to further refine the chin-neck angle is useful in rhytidectomy as well as cervical liposuction. Added benefit of the extended chin implants and cervical rhytidectomy helps to fill the furrow between the buccal soft tissue and the menton in patients where this is a problem (Fig. 6–34).

Numerous implant materials are available, and the choice is based on the personal preferences of the surgeon and patient.

Chin augmentation or mentoplasty is usually performed at the time of the submental approach for liposuction or trimming and imbrication for platysmal banding. The submental incision must be extended slightly further for the placement of the implant than for liposuction, but is comparable to the incision for platysmal imbrication. After the cutaneous incision is made, the skin is grasped and retracted anteriorly so that the incision through the subcuticular fat down to the menton can be made in a step pattern and is not immediately beneath the skin incision. This helps prevent scar contracture postoperatively.

The periosteum is incised and elevated laterally just above the margin of the mandible and inferior to the mental nerve. The mental nerve is identified and preserved. Centrally 1 inch of periosteum is left intact over the immediate menton to decrease the risk of bony erosion. The implant is then inserted with care to make sure that the distal portion of the extended implant is unfurrowed. The implant is then stabilized to the margin of the mandible and the incision is closed.

Complications

With augmentation procedures done as part of facial rejuvenation, the procedure performed and the implant material used dictate the complications. Autogenous grafts are less likely to present with significant compli-

cations but may resorb to an unpredictable degree. With alloplastic materials, technique as well as the material itself dictate the complications.

With the use of autogenous dermal grafts, fat grafts, and fascial implants, the most common complication is excessive resorption and an unsatisfactory result. Careful atraumatic handling of the graft material and avoiding wound complications such as hematoma or infection are vital to the survival of the implant material. The proper placement in a subdermal plane also helps to deter resorption. In addition to an unsatisfactory result, seroma, hematoma, and infection may occur.

Epidermal inclusion cyst can develop if the epithelium is not completely removed from the dermal fat fascial graft prior to insertion. Multiple techniques have been described for the removal of the epithelium. CO₂ laser vaporization is effective, but has a tendency to create extensive inflammation within the graft, exacerbating the postsurgical edema and creating a prolonged over-enhancement, which may take from 6 to 12 weeks to resolve. The increased inflammation caused by the laser epithelial removal may also exacerbate the resorption and lead to less effective augmentation in the long term. For this reason, it is preferable to de-epithelialize with a dermatome or No. 10 blade used in a freehand manner. This is best done with the graft in situ after the margins have been scored but prior to complete incision through the dermis. This allows better stabilization and makes it easier to develop a consistent plane of dissection.

Alloplastic materials are well tolerated but can be subject to extrusion. When placed in the melolabial fold, positioning is critical and placement of the graft in a subcutaneous pocket immediately beneath the dermis is imperative. The pocket size to be elevated should be adequate to avoid compression of the graft but avoid oversizing so that graft slippage does not occur.



FIGURE 6–34 (A,B) Preoperative and 1-year postoperative photographs after facelift and augmentation mentoplasty. Extended implants help with the elimination of the marionette lines.

LIPOCONTOURING

Contouring of the face and neck takes many forms from implant and osteotomies to redraping and fat resection. Techniques for the reduction of cervical facial fat include direct excision, liposuction, ultrasonic liposuction, and liposhaving. The use of injectable fat as a filling material remains popular, but it has not found its niche as a long-acting form of augmentation.

Changing the shape and contour of the cervical facial area with resection of fat was introduced in the 1970s by Schrudde.²¹ Since that time, multiple efforts have been made to improve its effectiveness, all based on the premise that subcutaneous fat reduction can take place safely using a blunt cannula when it is maintained in the proper plane. When liposhaving is performed, the amount of negative pressure is reduced because a cutting cannula is used to resect the fat, and suction is used only to remove it from the surgical field.²² Ultrasonic liposuction and externally applied ultrasound have evolved in an effort to enhance the results while reducing trauma and increasing the ease of surgical execution.

Lipocontouring has become an integral part of facial rejuvenation, standing alone in the young patient with lipodystrophy unresponsive to weight loss, and thick, elastic skin, as well as in the refinement of facial rejuvenation in older patients requiring a combination of skin excision and fat removal. Liposuction is commonly used as an adjunct to facelifting in an effort to mobilize a more extensive viable flap without interrupting the blood supply.

Lipocontouring is used primarily to enhance the cervical facial angle, define the jaw line, and reduce

jowl adiposity posterior to the marionette lines. Lowering of the melolabial ridge can also be accomplished. The principle behind the reduction of fatty deposits with the removal of adipocytes is based on the premise that after puberty fat cells no longer multiply and that weight loss or gain affects the size of individual cells and not the number. By reduction in the number of adipocytes, a permanent reduction in a region's ability to add fatty deposits is affected and mass can only be added to the remaining cells, transferring the control of the distribution of weight gain to other areas of the body.

Patient Selection

In evaluating patients presenting for lipocontouring, it is important to assess the degree of adiposity, skeletal structure, skin elasticity, and motivational factors. Evaluating the patient's determination to lose weight can address motivational factors. The results of liposuction are best when applied to fatty deposits that are resistant to weight loss. If the patient is willing to make the effort to lose weight, then that should take place prior to surgery, also giving an indication of the patient's motivation.

The skeletal structure needs to be evaluated and the patient informed presurgically of any abnormalities that might contribute to a suboptimal result, such as micrognathia or mandibular hypoplasia, a low anteriorly displaced hyoid bone, and malar hypoplasia. The patient must be made aware of these restrictions and offered possible remedies so that the limitations they present to a good postsurgically result are appreciated and possibly addressed (Fig. 6-35).



FIGURE 6-35 Preoperative (A) and 1-year postoperative (B) photographs after liposuction-assisted deep plane cervical facial rhytidectomy accompanied by endoscopic browlift and lower lid blepharoplasty.

Procedure

The procedures for liposuction and liposhaving are similar but have minor differences that are cited later. When these procedures are performed separately, they can be done with the degree of anesthesia that makes the patient comfortable. If facial and cervical liposuction are required, monitored anesthesia care or general anesthesia is recommended because of the necessity for diffuse infiltration and the vigorous nature of the procedure. If limited areas are to be addressed, then local anesthesia can be performed with regional nerve blocks and infiltration, which must extend well beyond the marked area for lipocontouring.

The patient is marked while in the upright and seated position. The distal extent of the fat to be resected is marked and an additional mark is placed 1 cm beyond this margin so that the surgeon is reminded to taper distally during liporesection.

After the patient is marked, anesthetized, and prepped and draped, a small submental incision is made. This incision can be extended if the procedure is to be combined with platysmal imbrication or chin augmentation. The incision is carried just into the subcutaneous tissue where initial passes are made, without applying a vacuum, to elevate multiple crisscrossing tunnels. Effort must be made to feather distally, as well as to create multiple entry tunnels to prevent overresection at a given site immediately adjacent to the incisions.

After multiple passes are made without aspiration and using a smaller cannula, the process is then repeated with the cannula that will be used. After all tunnels have been extensively elevated without the application of a vacuum, the vacuum is applied, concentrating on more lateral aspiration and tapering. This is important because as the cannula returns centrally with every pass, the tendency is for excessive fat resection centrally leading to a cobra-neck deformity. The surgeon must also concentrate on the symmetric application. For a right-handed surgeon, the tendency is to perform more passes on the left side and submental region because of the hand position. It is advisable to become ambidextrous with this procedure, so that application can proceed symmetrically. The tip of the cannula should routinely extend 1 to 1½ cm beyond the distal marked margin of fat to be resected to assure tapering. The cannula is then removed and the wounds palpated to assure the even removal of fat.

When this procedure is done in conjunction with platysmal imbrication, Metzenbaum scissors are used to separate the connective tissue septa, exposing the platysma muscle and allowing it to be addressed and sutured in the midline. The wound is then closed. It is not advisable to cross the mandibular margin from a submental approach during liposuction because this increases the risk of injury to the marginal mandibular branch of the facial nerve.

With liposhaving, it is imperative to keep the cannula in continuous motion to avoid overresection. Liposhaving is occasionally executed after the subcutaneous plane is elevated using scissors allowing direct visualization.

For addressing adiposity of the jaw, a small incision can be made in a pre- or postlobular crease. Again, multiple passes are made without the application of a vacuum. Here, it is imperative to avoid the recurrent passes of the cannula over the preauricular area and parotid fascia. On rare occasion will liposuction be necessary in this area, and if efforts are not made to avoid aspiration, a shallow trough or banded appearance can be created in the preauricular area.

From this small incision, it is also difficult to create the desired crisscrossing pattern over the jowl adiposity distally, necessitating a conscious effort to develop multiple approach tunnels with the cannula. Suction should not be applied while the cannula is in the approach tunnels over the parotid fascia because of the risk of creating striations.

If liposuction is performed in conjunction with a facelift, then the facial portion of the liposuction can be performed in an open or closed fashion. If an open fashion is chosen, the liposuction is performed after elevation of the skin flap, but prior to elevation of the SMAS or deep plane.

After completion of the liposuction, a bulky dressing is applied that remains in place for 72 hours. This dressing is then removed and the wound evaluated. A lighter removable dressing is given to the patient, who is instructed to continue to wear it as often as possible and every night for 3 weeks. Prescriptions for pain medicine and antibiotics are also given to the patient.

Complications

Liposuction has evolved as a safe surgical procedure, with most complications arising from errors of execution, including asymmetric resection, irregularities, banding, and overresection. Hematoma, infection, and scar contracture can develop regardless of technique.

Irregularities of the subcutaneous fat can be avoided following the techniques outlined previously. It is imperative to assure the symmetric execution as well as to avoid the excessive application of suction in the approach. Avoiding trauma to the undersurface of the dermis is also important in preventing abnormal scar contracture. Lipocontouring was developed with limiting complications in mind and has achieved that goal when used judiciously. A learning curve exists for consistent results, with outcomes from surgery as dependent on patient selection as on surgical technique. Unavoidable complications occasionally occur regardless of the surgeon's skill and technique and include infection, hematoma, seroma, bruising, skin numbness, and scar at the approach site.

These complications tend to be self-limiting and can be managed cautiously.

Seroma and hematoma are the most common uncontrollable complications, occurring less than 1% of the time. They are benign and self-limiting in nature and can be managed with evacuation when liquefaction has occurred. Expanding or malignant hematoma has not been reported with isolated liposuction. With ultrasonic liposuction or liposhaving, the risk of seroma and hematoma may be greater because of possible thermal damage and the cutting nature of the cannula, respectively. The incisions for closed liposuction are small and camouflaged in skin creases; therefore, adverse scars seldom occur and are easy to correct. Numbness of the overlying skin is more common in open liposuction than in closed liposuction and is self-limited, usually resolving in 8 to 12 weeks.

Skin contour irregularities usually reflect errors in patient selection or in execution. Skin irregularities result when excess or inelastic skin is not appreciated and can be exaggerated by the removal of fat. The subdermal application of the CO₂ laser²³ at the time of surgery may slightly tighten the skin but has not proven itself extremely effective or overly useful.

Dermal fibrosis is most likely to occur when the fenestra of the cannula is applied directly to the undersurface of the skin during lipocontouring. This leads to scarring, which requires flap elevation and autogenous grafting with fat and fascia to correct. Asymmetric contour, sharp contour, harsh transition, and the cobra-neck deformity are the consequences of surgical error resulting from inadequate peripheral feathering, long passes that recur over the submental area, and the disproportionate concentration of passes on one side. Subtle contour irregularities are usually easy to address with revision surgery. Cobra-neck deformity requires augmentation, which may be done in conjunction with platysmal imbrication accompanied by skin elevation and redraping.

SKIN RESURFACING

When all modern remedies to preserve the youthful texture of the skin wrinkle-free and without blemish have become ineffective, patients then begin considering resurfacing. Based on skin type and the degree of photoaging present, alternatives from glycolic acid and microdermabrasion to CO₂ laser and phenol can be considered. Selection is based on skin type using the Fitzpatrick scale²⁴ and Glogau classifications²⁵ while considering the patient's lifestyle, age, and tolerance for morbidity. A graduated approach is best, proceeding accordingly with all recommendations tempered by the patient's lifestyle.

It is universally accepted that skin protection begins at an early age using sunscreens that provide both

ultraviolet A and B (UVA and UVB) protection. This is best obtained with those sunscreens that contain micronized zinc or titanium.²⁶

In patients with mild photoaging who present with little wrinkling and no keratosis and who use little or no makeup, procedures involving the superficial layers or stratum corneum, glycolic acid, and microdermabrasion may be sufficient.

When more severe wrinkling or mild scarring occurs with early actinic keratosis, so that it is necessary for patients to wear some makeup, they are considered to have moderate photoaging that is best addressed with agents that may create an injury that extends to the papillary dermis. These agents include 35% trichloroacetic acid, a Jessner peel, and the application of glycolic acid in solutions greater than 20%.

With advanced or severe photoaging that may be represented by persistent wrinkling, discoloration with telangiectasia, actinic keratosis, gravitational and dynamic rhytids, and precancerous and cancerous lesions of the skin, it is best to consider these patients for a deep injury extending to the reticular dermis. This level of injury is obtained with a Baker's chemical peel, dermabrasion, or laser resurfacing.

At the time of presentation to the office for management of abnormalities of the skin surface, all patients are evaluated and a program for hygiene reflecting that recommended by Monheit²⁷ is initiated. This begins the preparatory process for deeper levels of injury if needed to affect a result. This preparatory phase includes the application of α -hydroxy acids, hydroquinone, retinoic acid, and vitamin C. For patients who require more aggressive management, including dermabrasion, the CO₂ laser or a Baker's peel is considered, and a 4-week course of hydroquinone and retinoic acid is initiated to assist in the recovery and to avoid postsurgical complications.

LASER RESURFACING

Laser resurfacing has become the stalwart for addressing advanced and severe photoaging. The use of the laser as a technique for resurfacing was initiated in the 1980s and has matured with improvements in the mechanism of application.

The wavelength determines the absorption of laser energy, whereas the exposure time determines the thermal diffusion. The power density or irradiance is measured in watts per centimeter squared, whereas energy density or fluence is measured in joules per centimeter squared. With the application of lasers, the exposure time is the key to avoiding thermal injury and should remain less than the thermal relaxation time for the tissue being treated. The CO₂ laser with a wavelength of 10,600 nm and the erbium yttrium-aluminum-garnet (YAG) laser with a wavelength of 2940 nm are most

effectively absorbed by water, leading to the vaporization of the epidermis and superficial layers of the dermis. The CO₂ laser does have a tendency to create a broader zone of thermal injury, which is thought to lead to superior results as a consequence of collagen realignment, and shrinkage does not occur to the same degree as with an erbium laser. The erbium laser became popular in an effort to avoid prolonged healing time and prolonged erythema, but while accomplishing this goal it was ineffective in obtaining the same results as a CO₂ laser. To obtain comparable results with the CO₂ laser, deeper injury is required, resulting in a longer acute healing phase, and persistent erythema resulted with the erbium laser, providing little benefit over the CO₂ laser in resurfacing.

Patient Selection

Patient selection for laser resurfacing and any resurfacing technique that would create an injury to the level of the reticular dermis is based on need and skin type. The need was elucidated earlier, with most patients having advanced or severe photoaging. The skin types that can be addressed safest with the level of injury created with CO₂ laser are Fitzpatrick types I and II. The use of ablative resurfacing techniques in skin types III through VI is more likely to result in complications.

After consultation, patients undergo 1 month of pretreatment, which includes the education regarding sunscreen and lifestyle modifications. Patients are acutely pretreated with antibiotics, antifungals, antivirals, and antiinflammatory medications, all of which are initiated prior to the application of a deep resurfacing technique.

With patients for whom chronic sun exposure is a problem and lifestyle modifications are not expected, deep resurfacing techniques should be avoided. These patients are more likely to have acute postoperative hyperpigmentation and prolonged postoperative hypopigmentation, which responds poorly to management.

Because of the tendency for subtle but evident compromise in the pigmentation of the skin with deep resurfacing, it is now more common to recommend some form of resurfacing to address the entire face, tapering in the hairline, and angle of the mandible. This can be accomplished by the lighter application of the laser, or a combination of laser and dermabrasion, or with more superficial chemical peels peripherally. The regional or segmental application of deep resurfacing techniques can lead to marionette shadowing in the perioral area and raccoon mask pigment modifications in the periorbital area. Most commonly segmental laser resurfacing is performed in conjunction with surgical facial rejuvenation where resurfacing and flap elevation needs to be avoided to prevent compromise to the skin integrity. For patients who want to address skin laxity as well as perioral rhytids, segmental resurfacing is considered. If a facelift is not to be performed but rather a browlift or lower lid blepharoplasty is chosen, resurfacing can be performed at the same time.

Technique

After the patient has undergone adequate skin preparation, surgery is scheduled. Presurgical administration of antiinfectious and antiinflammatory agent is routine. The patient is taken to the operating suite after the rhytids and the mandibular margin are marked. Monitored or general anesthesia is performed. The patient's skin is prepped and draped and the eyes protected with froth suture or ocular shields. Because of the difficulty obtaining a complete regional nerve block and infiltration anesthesia, general anesthesia tends to expedite surgical execution and enhances patient comfort.

The margins of any deep rhytids are first removed. After the margins of specific rhytids are lowered, the eschar in the case of a CO₂ laser is removed. After removal of the eschar, an additional two to three passes with tapering at the margin of resurfacing are performed (Fig. 6–36). These are performed to a level where cham-*mois*-cloth coloration to the skin occurs, representing injury to, but not through, the reticular dermis. Eschar is removed between each pass (Fig. 6–37). Efforts are made during the application not to overlap sites exposed with the laser. When performing erbium laser resurfacing, it is imperative to follow a specific pattern of exposure because after the first pass it is difficult to assess which sites have been treated.

After completion of resurfacing, patients can be treated with a closed or open technique for management of the wound. In my experience, patients are unable to care for this complex injury and I prefer a closed technique with the application of a petroleum-based ointment to the skin covered with a nonadhesive Teflon dressing and a layer of absorbing gauze.

Postoperatively, a dressing (Fig. 6–38) remains in place for 48 to 72 hours after being changed on the first postoperative day. Patients frequently have to care for the perioral and periorbital area with the application of ointment and intermittent soaking with a dilute solution of vinegar and distilled water. The mobility of the perioral and periorbital area prevents reliable coverage with a closed technique. Patients are maintained on antibiotics and antiviral medications until epithelialization has occurred, which is usually at 10 to 14 days.

The postsurgical dressing is removed at 24 hours and a clean dressing applied, which remains in place for 2 to 3 days. After removal of the dressing, the patient is then started on extensive wound care with frequent cleaning with gauze and a vinegar and water solution followed by the application of petroleum-based ointment. Antibiotic ointments should be avoided because of the likelihood of atopic dermatitis developing. The patient performs wound care every 2 to 4 hours during the waking hours. As the wound epithelializes at 10 to 14 days, a more mild form of moisturization can be used with discontinuation of petroleum-based products.



FIGURE 6-36 (A) Preoperative marking of the margins of acne scars. (B) Eschar after the first regional pass with the CO₂ laser.



FIGURE 6-37 Full-face laser resurfacing with extensive eschar prior to its removal.

Retin-A and hydroquinone should be reinitiated at 4 to 6 weeks after surgery. This is done incrementally to avoid irritation from these medications. The avoidance of sun exposure is imperative for 6 months after surgery.

Complications

Complications can almost be considered a consequence of laser resurfacing and are best addressed if anticipated and controlled. In the acute postoperative period, marked facial edema develops, with the possibility of severe perioral and periorbital edema developing, leading to the inability of patients to open their eyes and creating



FIGURE 6-38 Full-face dressing post-laser resurfacing, which remains in place for 48 to 72 hours. The absorbent gauze is over a Teflon mesh dressing and a petroleum-based wound care product.

difficulty with taking nutrition by mouth. This severe edema usually resolves within 24 to 48 hours and can be reduced with the application of perioperative steroids. Infectious complications are a risk and remain present up to the time that reepithelialization occurs. For this reason antibacterial, antifungal, and antiviral medications are extended for 14 days postoperatively.

Changes in the pigmentation of the skin occur with deep resurfacing. This may take the form of hypo- or hyperpigmentation. At the time of surgery, efforts are

made to taper the depth of injury at the margins of the laser exposure to have a subtle transition between treated and untreated skin. Efforts also should be made to have this transition occur in shadows and at the junction of facial aesthetic subunits. Hyperpigmentation is most commonly a transient complication that usually resolves by 6 months and can be managed with the application of bleaching agents. Hypopigmentation, however, is frequently a delayed manifestation of deep resurfacing and does not respond to management, necessitating efforts to lighten adjacent skin with bleaching agents or more superficial forms of resurfacing such as a trichloroacetic (TCA) peel and the erbium laser.

Scarring may develop from injury to the reticular dermis or a postsurgical infection. Scar can be managed with the topical application of steroids, silicone patches, and steroid injections. They most frequently develop from the overlap of exposures. Scarring can lead to lid retraction and ectropion that may resolve with massage or steroid injection, or require skin grafting.

Deep resurfacing is a vital component of facial rejuvenation, but must be used prudently with extensive presurgical patient education regarding risks and complications and the patient's realization that postsurgical care will be cumbersome, the healing process will be prolonged, and modifications in lifestyle to avoid sun exposure will be necessary.

LIP ENHANCEMENT

Lip enhancement has become an integral part of rejuvenation as well as for enhancement of the overall appearance. As we age, the loss of subcutaneous and submucosal fat leads to the decrease of red lip show and the loss of bulk. Congenitally, small lips may be present over a lifetime and can become exacerbated. Any efforts to enhance the lip must consider its supple, mobile, and animated characteristics during the evaluation, and correction.

The melolabial fold, nasal base, mental crease, and buccal mucosa bound the lips. The shape and proportion vary dramatically. Balanced proportions between the upper and lower lip are represented by the upper lip being 70 to 80% the size and fullness of the lower lip. The shape of the lip may vary. Most consistently the upper lip is considered to be a flattened **M** with the peaks at the philtral column and the lower lip a flattened **U** or **W**. The most common shape of the lower lip is a flattened **U**. The position, contour, and shape of the lips are also impacted by the status of the alveolar ridge and dentition. Any effort to enhance the size of the upper and lower lip must consider maintaining natural animation and texture while enhancing the contour and size.

Techniques

Lip enhancement may take the form of augmentation or advancement. Augmentation can be obtained with

injectable materials, autogenous materials such as fat or dermal fat fascial graft, and alloplastic materials such as e-PTFE or homogeneous acellular graft. All these materials have advantages and disadvantages from the standpoint of ease of application and long-term results.

Injectable materials should be considered temporary, even when using autogenous fat. All injectable materials should resorb. Cory Maas states, "Permanent injectable materials have the distinct limitation of irreversibility."²⁸

The application of alloplastic materials in lip augmentation is to be discouraged at the present time. Threads can effectively be used to enhance the vermilion border. Even in this application, stiffness and distortion on movement, as well as rigidity to the lip may develop. Alloplastic materials have the advantage of removability.

Acellular dermal grafts remain supple after placement, are easy to use, and can be used safely with few complications. They seldom cause movement irregularities in a lip or the restriction of motion. Their drawback is that they have not been demonstrated to affect permanent augmentation and may only produce augmentation for 18 to 24 months.²⁹ Dermal fat fascial grafts or temporalis fascial grafts are very effective and can be used to obtain dramatic augmentation of the lip, but undergo varying degrees of resorption. If permanent dramatic enhancement is desired, dermal fat fascial grafts are effective. They may be harvested from the suprapubic region in a female, taking advantage of preexisting cesarean section or hysterectomy scars, and from the gluteal crease in males because of the minimal number of hair follicles in this region.

For obtaining the most natural, fastest-healing lip enhancement with the fewest complications, the technically challenging **V-to-Y** buccal advancement flap is unparalleled. Although reliable permanent enhancement can be obtained, the degree of augmentation may be subtle (Fig. 6-39). For patients who have a disproportionate height of the white upper lip, a lip roll with efforts to preserve the vermilion border can be effective. Subnasal skin excision should be avoided in that the nasal base can be distorted and an evident scar will be created.

Lip enhancement through augmentation is performed following the same technique regardless of the material utilized. In most cases, local anesthesia or local anesthesia with oral sedation is adequate. If augmentation is to be executed at the time of other rejuvenative procedures, then the level of anesthesia is dictated by those procedures. Prior to infiltration of the upper and lower lip, the contact point, or wet-dry junction is marked (Fig. 6-40). The patient is then taken to the operating room where infiltration is performed. The minimal amount of infiltration to obtain complete anesthesia is used. This usually requires 2 to 3 mL on each lip. A midline incision is made extending from slightly anterior to the wet-dry junction for ~1 cm posteriorly. A deep submucosal tunnel is then



FIGURE 6-39 The goal of lip augmentation should be to obtain enhancement while maintaining the natural appearance, mobility, texture, and softness of the lips. (A) Preoperative photograph prior to a V-Y lip advancement. (B) One-year postoperative.

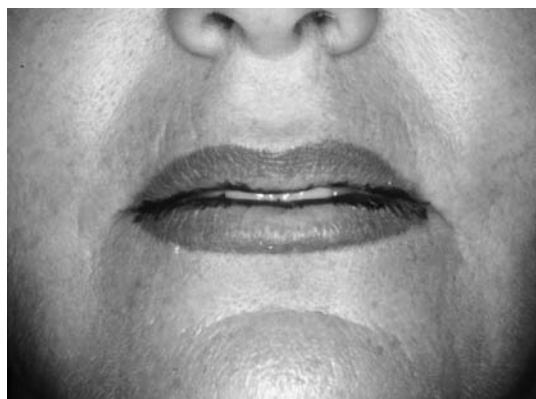


FIGURE 6-40 Marking the wet-dry junction preoperatively.

elevated using the tenotomy scissors extending 2 mm anterior to the wet-dry junction and posteriorly along the buccal surface of the lip with the total width of the tunnel being 1 cm centrally and tapering laterally to 3 to 4 mm, with the elevation of the tunnel extending beyond the oral commissure.

A Frazier suction is inserted into the tunnel and a Keefe needle with a 3-0 silk suture is passed into the end of the Frazier suction and drawn into the tunnel and out through the medial incision. The Keith needle is then passed through the end of the implant material, bringing with it the free end of the silk suture. The silk is then tied loosely 2 to 3 inches from the end of the graft, and then the suture is withdrawn and the graft drawn into the tunnel. For dermal fat fascial grafts, the dermal surface remains superficial. The silk suture is tied loosely so that adequate length of suture can be drawn through the stab wound and sutured to the draw suture of the lower lip to maintain the graft in position. After this is done bilaterally, the anterior border of the graft is sutured to the deep surface of the vermillion border to hold the graft anteriorly, and the incision is closed with 4-0 chromic sutures. The procedure is then repeated on the lower lip (Fig. 6-41).

For the buccal mucosal V-to-Y advancement, again the wet-dry junction is marked with the lips in a relaxed position. Buccal mucosa must be dried with gauze. Anterior mucosa is marked in the midline at the base of the philtral column and at even increments laterally to the level of the oral commissure (Fig. 6-42A). After these marks are placed externally, the V's are marked on the buccal mucosa not crossing the wet-dry junction with the apex of each V at the corresponding site on the dry mucosa marked externally (Fig. 6-42B). This usually results in four to five V incisions lateral to the midline. After this is marked, gauze is left in place to prevent it from smudging. The marks extend from the wet-dry junction posteriorly into the buccal mucosa for 1 to 1½ cm centrally tapering laterally, with the most lateral V limb being 4 to 5 mm in length and placed lateral to the lateral commissure. The patient's lip is then infiltrated.

After anesthesia is obtained, the incision is made. Submucosal elevation of the anterior flaps is then performed, including the submucosal elevation of the dry mucosa (Fig. 6-42C). After elevation is completed, the flaps are advanced and sutured into position with interrupted 4-0 chromic sutures. The degree of advancement can be adjusted to customize the contour and the enhancement. A Gillies-type corner stitch can be used to approximate the tip of the flap, and this is usually placed first followed by interrupted sutures on each limb of the flap (Fig. 6-42D). The technical execution of this procedure is rather tedious but it remains my favorite technique for lip enhancement because of its natural appearance and animation (Fig. 6-39). The postoperative care in lip advancement includes the application of cold compresses, a soft diet, cleaning with hydrogen peroxide, and the application of antibiotic ointment to all exposed sutures for 72 hours after surgery.

In patients with a disproportionately high upper lip, lip roll with vermillion advancement is executed (Fig. 6-43). The overall result is superior to resection of upper lip skin at the nasal base. The skin to be excised

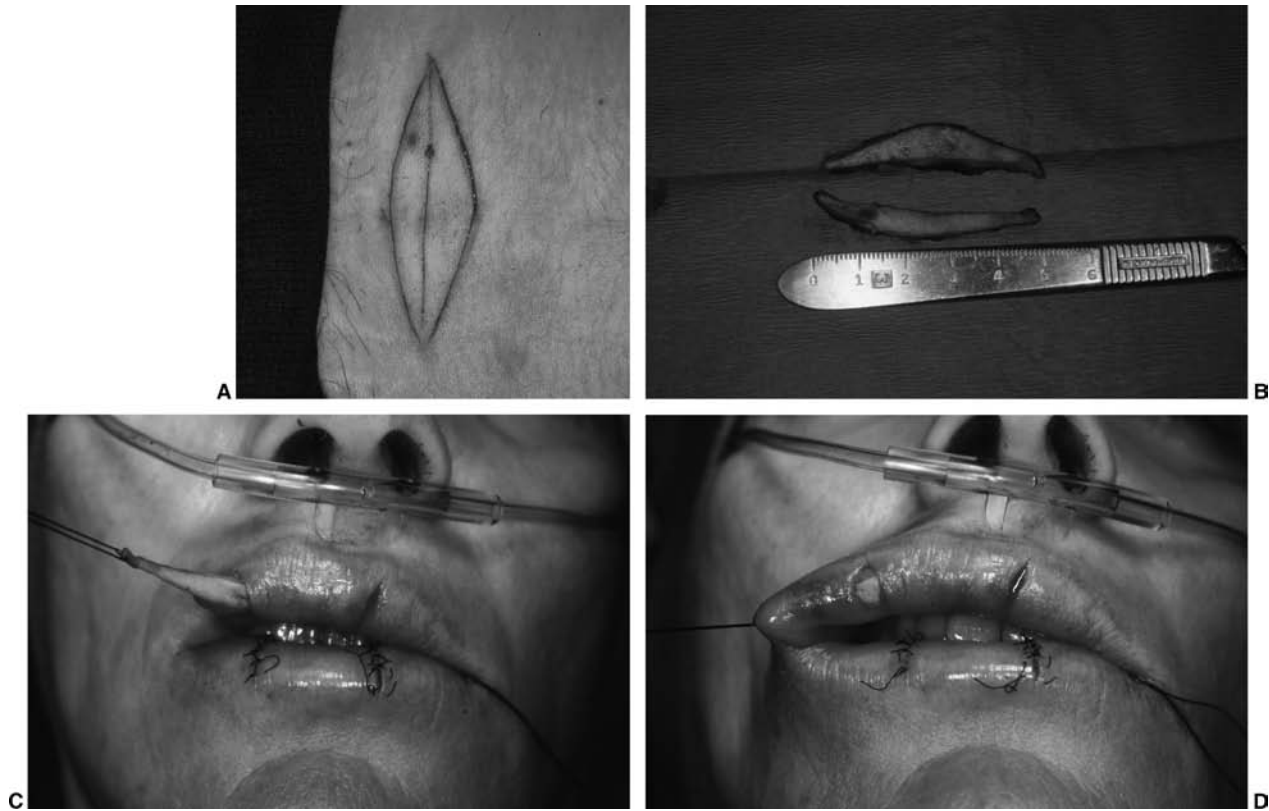


FIGURE 6-41 (A) Marking the suprapubic site for dermal fat fascial grafts in lip augmentation. (B) The dermal fat fascial grafts after removal of the epithelial. (C) Graft placement in the deep submucosal plane of the lip, with (D) stabilization at the oral commissure with silk draw sutures.

is marked prior to infiltration, with the inferior mark immediately above the vermillion ridge. After the incisions are made, excise only epidermis and the most superficial layers of the dermis. This allows the subincision enhancement with deep layers of the dermis. The vermillion border and dry mucosa are elevated in a subcutaneous submucosal plane and sutured superiorly with interrupted 5-0 Vicryl sutures and a running subcuticular nylon suture. The incision may also be resurfaced with a dermabrader or laser to further camouflage the scar (Fig. 6-44). With this procedure, every effort should be made to enhance the cutaneous-cutaneous junction and avoid a postsurgical scar along the lip.

Complications

Complications with buccal mucosa V-to-Y advancement flaps or lip roll and vermillion advancement are infrequent and generally represented by unacceptable scar formation during the healing process. With V-to-Y advancement, occasional intraoral granulations develop and can be addressed with excision or cautery. There is some postsurgical hypesthesia, which typically resolves within 6 to 12 weeks. Mobility abnormalities have not been encountered. Some patients complain of a tight,

restricted lip while smiling, but this is self-limited. Massage and stretching of the lip can expedite its resolution.

Lip augmentation with a dermal fat fascial graft can occasionally lead to epithelial inclusion cysts, which are addressed through simple incision and curettage. The use of alloplastic materials consistently leads to irregularities in lip contour on animation. This cannot be avoided or corrected without the removal of the implants. Overaugmentation may occur with any technique and it necessitates the reduction in bulk of the graft. With dermal fat fascial grafts, this can occasionally be accomplished with steroid injections. Lip augmentation is a marvelous adjunct to facial rejuvenation and enhancement, but it must keep the suppleness and mobility of the lips in perspective.

Rejuvenation of the aging face must integrate excision, volume reduction, and augmentation to achieve the most natural result with the greatest potential for longevity. Liposuction, chin, lip, melolabial fold and malar augmentation, and resurfacing must all be considered in facial rejuvenation along with the patients expectations (Figs. 6-45 and 6-46).

On occasion the more direct approach to rejuvenating a specific site should be considered. There is no more

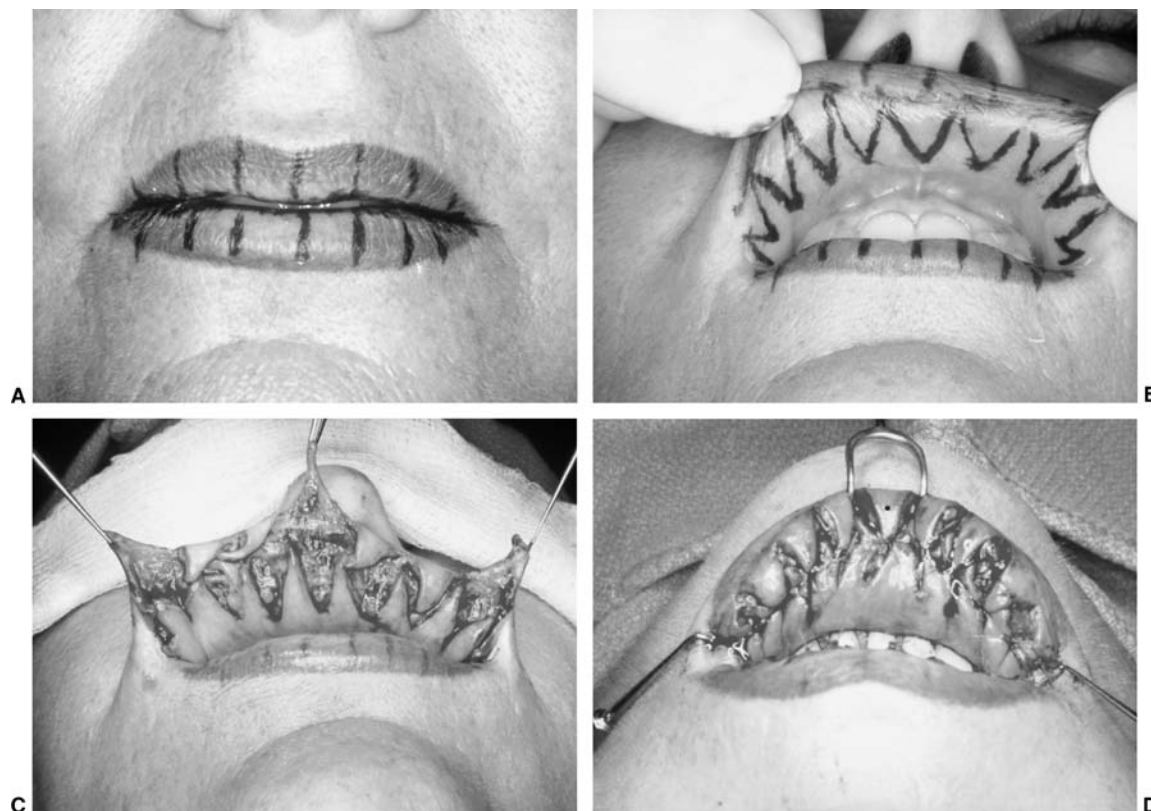


FIGURE 6-42 Lip advancement with multiple V-to-Y plasty is technically challenging but yields the most natural result in the shortest period of time. (A) Equally spaced markings on the external lip, which assist in the placement of (B) the buccal mucosal marks. (C) Submucosal elevation of the anterior flap and (D) the interdigitation with corner sutures using absorbable suture.

appropriate place than the submental wattle. When this is an isolated concern, the direct excision of submental skin with platysmal imbrication should be considered (Figs. 6-47, 6-48, and 6-49).

OTOPLASTY

Protruding ears or lop-ear deformity affects about 3 to 5% of the population. It can present a source of ridicule for young men and women alike.

The ear develops from six auricular hillocks surrounding the first branchial cleft.³⁰ Three of these hillocks exist in the mandibular or first branchial arch and three develop in the hyoid or second branchial arch. These hillocks begin to fuse and form the external ear. Assigning a specific anatomic location on the ear to any given hillocks is more speculative, but it is generally thought that the tragus helical crus and part of the helix develop from the mandibular arch and the remainder of the external ear develops from the hillocks of the hyoid arch.

The external ear is composed of the auricle, external meatus, and squamous part of the tympanic membrane. The cartilage of the external ear is elastic in nature.

The angle between the mastoid and external ear in a normal individual is 30 degrees. Protrusion of the helical rim, at the level of the junction between the superior and inferior crus of the antihelix, is 2 ± 0.5 cm. The angle formed at the antihelix between the posterior wall of the concha and the scaphoid is 90 degrees. Lop-ear deformity can present with multiple variations and combinations including a deep conchal bowl, absent antihelix, absent inferior and superior crus of the antihelix, and unfurrowing of the helical rim.³¹

Multiple other deformities of the external ear range from its absence in microtia, a small cupped ear, various configurations of the auricular cartilage, as well as an oversized ear. Numerous grading systems have been proposed, none of which has been universally accepted. Any surgical approach to correction of the lop-ear deformity should make every reasonable effort to establish a normal contour to the external ear tempered by the goal of eliminating a distraction rather than creating a perfectly contoured external ear. With this in mind, efforts should be made to avoid disrupting the cartilaginous continuity, blunting the postauricular sulcus, and changing the angle of the external auditory meatus.

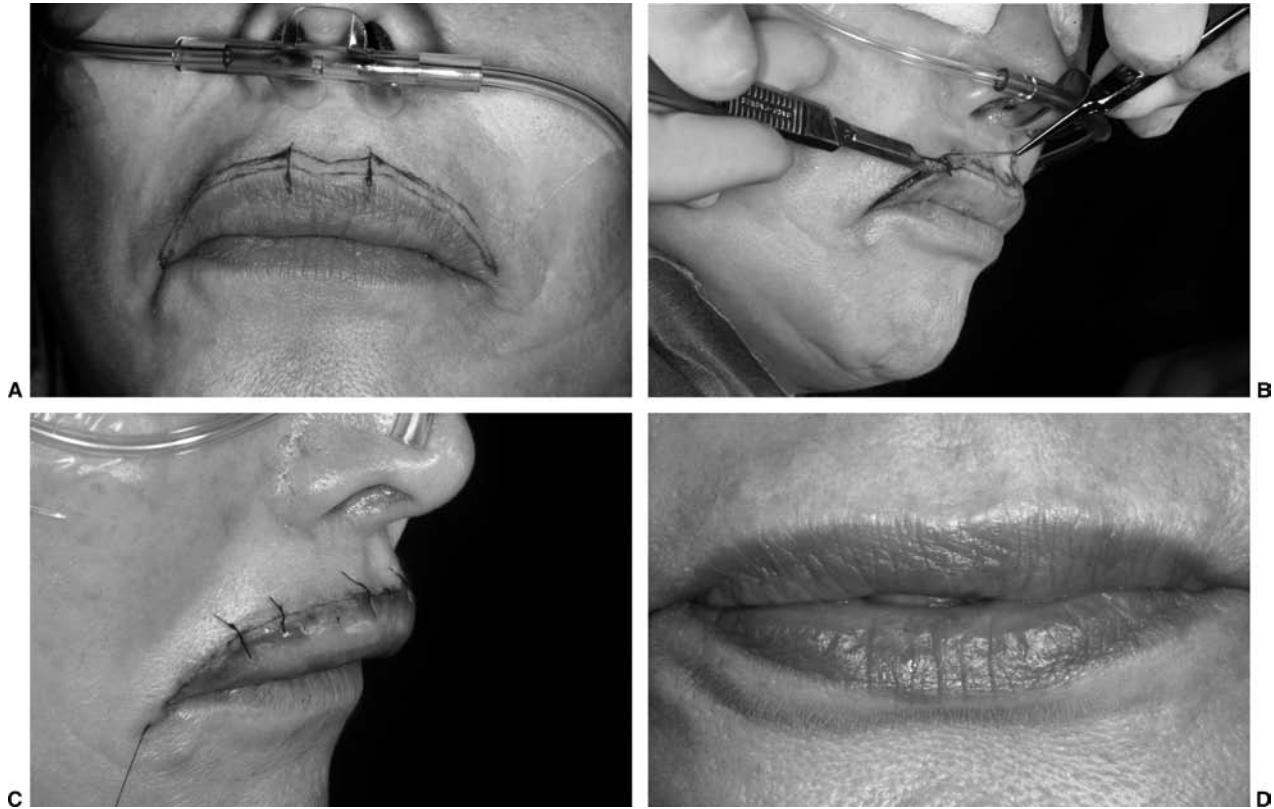


FIGURE 6-43 Lip roll with the direct excision of epidermis and superficial dermis adjacent to the vermilion ridge. (A) Preoperative marking exaggerating cupid's bow. (B) Excision of the epidermis and superficial dermis maintaining the deep dermis to enhance the vermilion ridge when closed. (C) Closure after inferior submucosal elevation with interrupted subcuticular Vicryl sutures and a running subcuticular nylon suture. (D) Close-up photograph 1 year postoperatively demonstrating excellent scar.



FIGURE 6-44 (A) Preoperative and (B) 1-year postoperative photograph of the patient in Figure 6-43.

Technique

The surgical approach to addressing protruding ears should be the least disruptive, and most anatomically correct, while avoiding disruption of the anterior skin and cartilage, especially over prominences such as the antihelix. The approach should be graduated according

to the age of the patient and the deformity. The step-wise incorporation of each technique beginning with conchal setback, suture techniques, conchal reduction, and scoring are dependent on the age of the patient, the anatomic abnormality, and the resilience of the cartilage.³²



FIGURE 6-45 (A) Preoperative and (B) 1-year postoperative photographs after dermal fat fascial augmentation of the lip, browlift, lower lid blepharoplasty, and deep plane facelift demonstrating the complementary effect of multiple procedures to rejuvenate the face.



FIGURE 6-46 (A) Preoperative and (B) 5-year postoperative photograph following laser resurfacing of the forehead, perioral and periorbital area in conjunction with a deep plane cervical facial rhytidectomy. The results have been maintained by the periodic application of botulinum toxic in the corrugator muscle and lateral orbicularis oculi muscle.



FIGURE 6-47 Direct excision of the submental wattle. (A) Preoperative. (B) One-year postoperative.

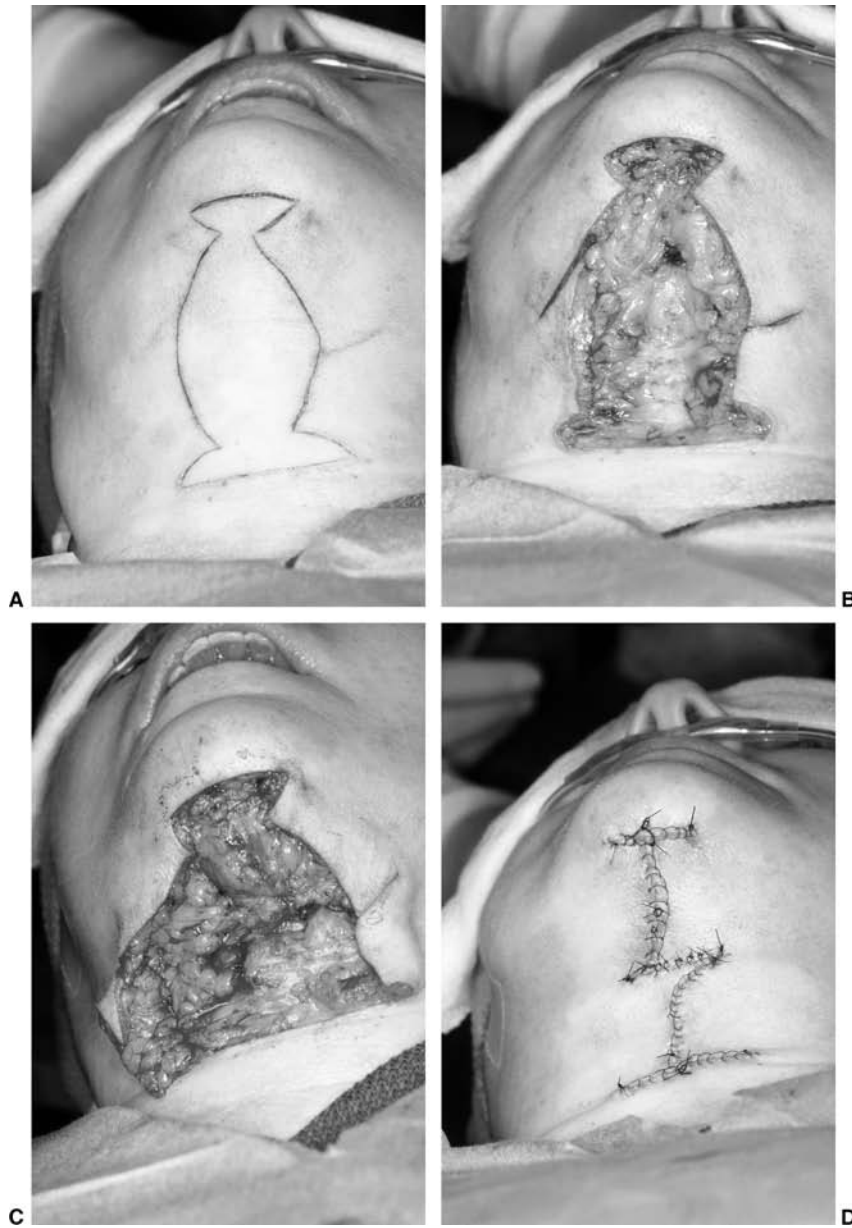


FIGURE 6-48 (A) Preoperative marking for the direct excision of the submental wattle resembling a Grecian urn. (B) After skin and subcutaneous fat excision. (C) Platysmal imbrication. (D) Layered skin closure with Z-plasty at the cervical mental angle.

The approach can be graduated from infancy through adulthood.³³ In an infant with a normal-sized ear and an absent antihelix, the deformity may be managed with percutaneous sutures and a bolster. In older individuals with more prominent ears and more rigid cartilage, scoring, conchal reduction, suture techniques, trimming, and extended incisions may occasionally be necessary.³³

Most otoplasty can be performed under local anesthesia with oral or intravenous sedation. A periauricular nerve block is performed using 1% lidocaine with epinephrine. After complete periauricular block is established, the posterior surface of the ear beneath the elliptical dumbbell excision is infiltrated with 1% lidocaine and 1:100,000 epinephrine. After the patient is prepped and draped with both ears exposed, an elliptical dumbbell

is excised on the posterior surface of the ear, including subcutaneous fat and fascia (Fig. 6-50A,B). If a conchal setback is to be performed, the skin medially over the posterior surface of the conchal bowl is elevated, hemostasis is obtained, intervening soft tissue between the concha and mastoid is resected, the posterior medial surface of the concha is trimmed, and Mersilene sutures are used displacing the conchal bowl medially and posteriorly to avoid angulations of the external auditory meatus.³⁴ This is the approach for ears that protrude and are flaccid with a deep conchal bowl and the presence of an antihelix.

If the antihelix is absent and the cartilage is still soft, then conchal setback with a Mustarde suture³⁵ to re-create the antihelix can be performed. By placing the skin excision on the posterior surface of the auricle, and lateral to the sulcus, blunting of the postauricular sulcus is avoided.

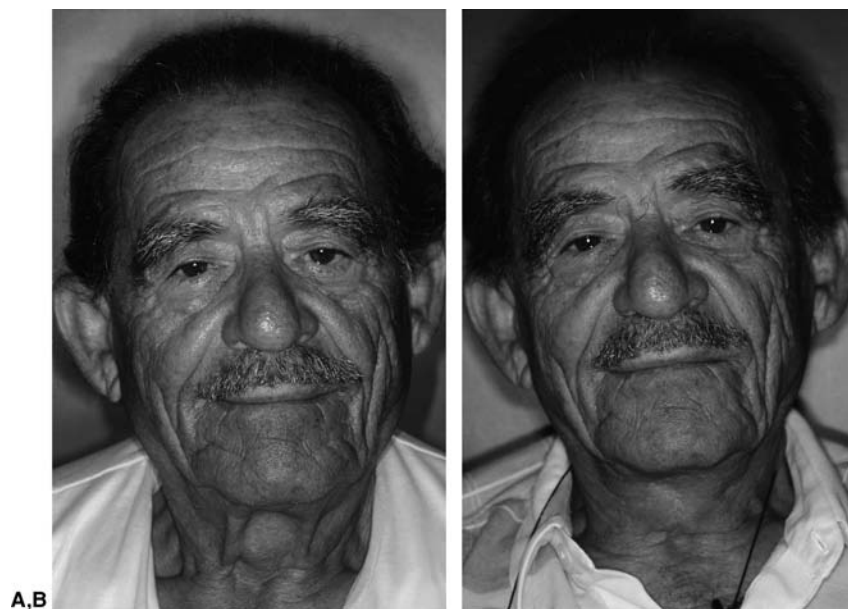


FIGURE 6-49 (A) Preoperative and (B) 1-year postoperative photographs of patient having undergone Grecian urn submental wattle excision.

In patients with rigid cartilage, a more aggressive approach may be necessary in addressing the protruding ear. Patients who have more rigid cartilage, a deep conchal bowl, and the presence of an antihelix, conchal reduction can be performed (Fig. 6-50E,F). When the antihelix is absent and there is a deep conchal bowl, conchal reduction with suturing and scoring of the posterior surface of the auricular cartilage may be necessary (Fig. 6-50G,H). Conchal reduction is performed with the resection of a fusiform strip of cartilage medial to the antihelix in the conchal bowl. The width of this strip can be adjusted to create symmetry in the depth of the conchal bowl from one side to the other. In the extremely rigid ear, it may be necessary to extend the incision along the inferior crus of the antihelix, freeing the helix anteriorly beneath the helical crus and extending the incision superiorly and posteriorly. This drastic measure is seldom needed.

In patients with a rigid external ear and a normal conchal bowl with an absent antihelix, suturing and scoring are effective. When the lobule protrudes, it may be corrected by mobilization of the cauda helices or by the trimming of the lateral surface of the cauda helices (Fig. 6-50C,D).

When using a suture technique to re-create the antihelix, mattress sutures are placed from the posterior surface of the scaphoid fossa, the scaphoid eminence, to the lateral surface of the conchal bowl immediately medial to the antihelix. These sutures are routinely placed in a vertical mattress fashion using 4-0 Mersilene. If conchal reduction is performed, the sutures are placed between the incision of the medial surface of the antihelix and the lateral edge of the conchal bowl extending in a vertical mattress fashion to include the scaphoid eminence.

When conchal reduction and scoring of the external cartilage is performed, Keith needles are used to mark the anterior border of the superior crus of the antihelix, the junction of the superior and inferior crus of the antihelix, the desired posterior margin of the antihelix, and the margin of the antihelix at the antitragus. When conchal reduction is performed, it is critical to avoid crossing the inferior crus of the antihelix. The posterior surface of the antihelix, the antihelical fossa, is scored with the excision of thin, partial-thickness wedges of the posterior surface to allow scarring and fibrosis and enhance the stability of the reduction. When the vertical mattress sutures are placed, they are done in a radiating pattern from the external auditory canal (Fig. 6-50H,I).

A cupped-ear deformity of the external ear can be managed through the lateral portion of the postauricular incision mobilizing skin off the posterior and anterior surface of the auricle. After skin is mobilized, the cartilage can be evaluated. A strip of autogenous cartilage harvested from the conchal bowl is used to splint the released helix. For oversized ears, numerous patterns of excision of excess auricular cartilage have been described, including the stellate excision of portions of the scaphoid fossa and superior crus of the antihelix.^{36,37}

Postoperative Management

All patients are kept in a head dressing for 5 days postoperatively. This dressing is usually changed the second or third day to evaluate the ear.

The dressing is applied after the wounds are closed, antibiotic ointment is placed on the posterior incision, and mineral oil-impregnated cotton is used to maintain the postauricular sulcus and pack the conchal bowl, fossa triangularis, and scaphoid fossa. After the cotton is placed, a fluff gauze dressing is applied over the external

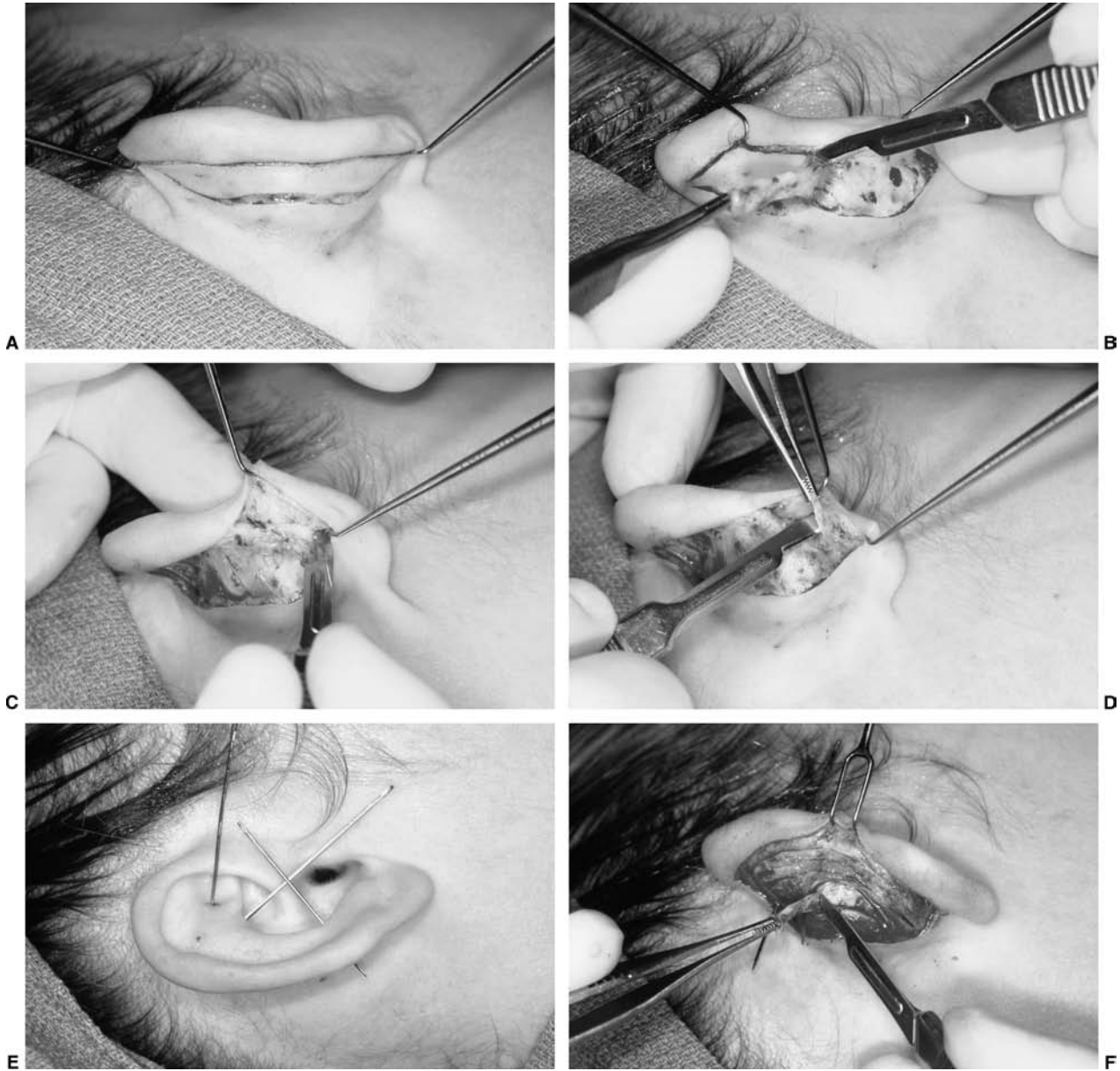


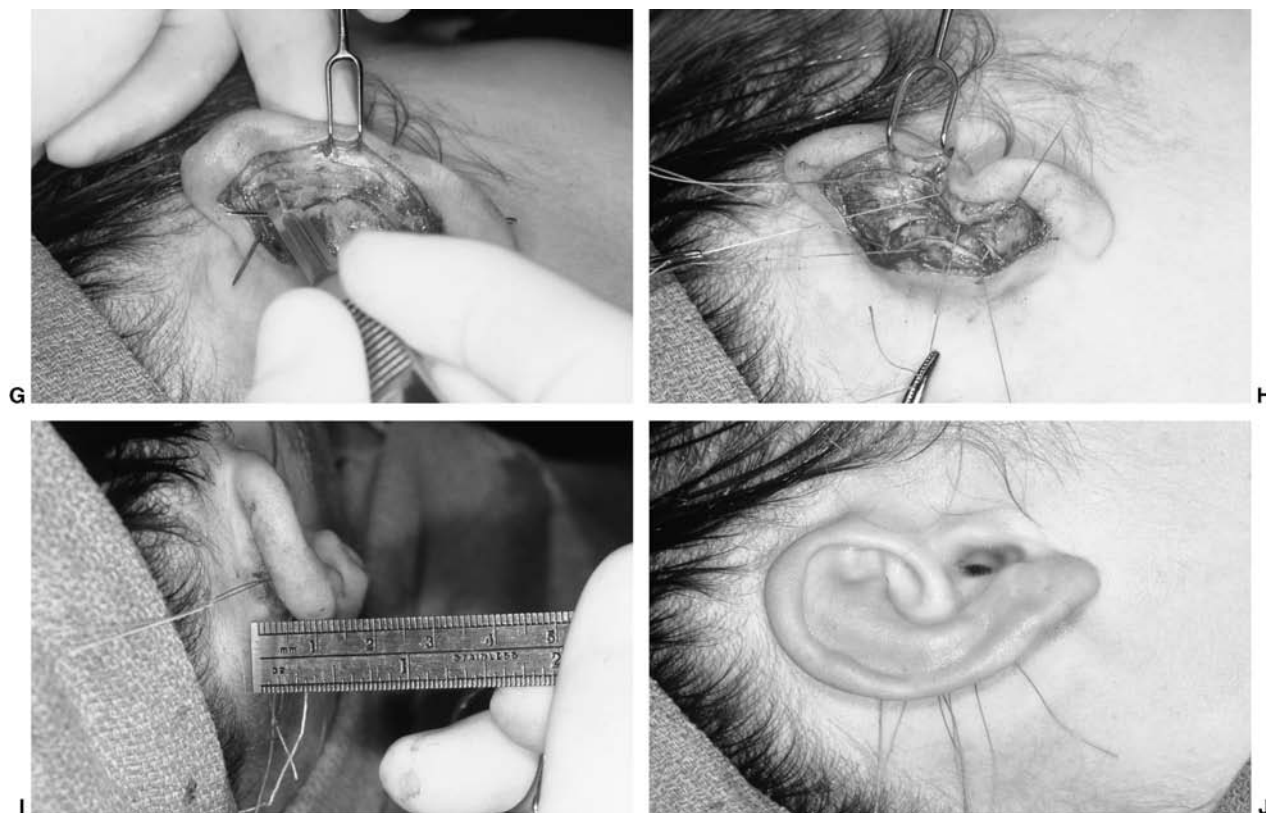
FIGURE 6-50 (A) Elliptical dumbbell skin excision for otoplasty. (B) Excision of skin and subcutaneous tissue. (C) Subcutaneous mobilization of postauricular skin over the cauda helices. (D) Trimming of the cauda helices. (E) Percutaneous marking of the anterior landmarks of the ear with Keefe needles at the junction of the superior and inferior crus in the fossa triangularis, the lateral extent of the conchal bowl at the bifurcation of the antihelix, and at the antitragus. (F) Excision of an ellipse of conchal cartilage immediately adjacent to the antihelix. (G) Scoring of the posterior surface of the superior crus of the antihelix and of the posterior surface of the antihelix. (H) Placement of vertical mattress sutures from the posterior surface of the scaphoid fossa to the medial margin of the antihelix and to the lateral margin of the conchal cartilage being placed in a radiating pattern. (I) Measuring the projection of the pinna from the mastoid. (J) Assessing the lateral contour to assure creation of an antihelix and a natural contour without irregularities.

auditory canal and a wrapped dressing using Kerlix, Kling, and half-inch adhesive tape is applied. After the dressing is removed, patients are instructed to sleep with a headband for 6 weeks after the surgery to avoid trauma to the external ear. Patients are also instructed to avoid contact sports or sports where possible injury to the external ear may occur such as football, basketball, and

soccer. These activities are restricted for 6 weeks after surgery (Fig. 6-51).

Complications

Complications with otoplasty are not infrequently the consequence of poor surgical planning, although some may be unavoidable. Anterior surface irregularities,

**FIGURE 6-50** Continued.**FIGURE 6-51** (A) Preoperative and (B) 1-year postoperative photograph after conchal reduction with suturing.

obliteration of the postauricular sulcus, telephone-ear deformity, and bowstringing of the posterior sutures are abnormalities that can be avoided with the meticulous execution of surgical technique.

Hematoma, suture extrusion, keloid, or hypertrophic scar complications may occur regardless of surgical technique.

Anterior surface irregularities and the obliteration of the postauricular sulcus are quite difficult to correct, and, unless grotesque abnormalities exist, the results may not justify attempts at surgical reconstruction. The telephone-ear deformity can be addressed and corrected with release of the central portion of the ear or further reduction inferiorly and superiorly.

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